

**Installation Restoration Program (IRP)
Final Phase II RI/FS Work Plan**

**143rd Combat Communications Squadron
Seattle Air National Guard Station
Washington Air National Guard
Seattle, Washington**

July 1998



**Air National Guard Readiness Center
Andrews AFB, Maryland**

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**Installation Restoration Program (IRP)
Final Phase II RI/FS Work Plan**

**143rd Combat Communications Squadron
Seattle Air National Guard Station
Washington Air National Guard
Seattle, Washington**

July 1998

Prepared For:

**Air National Guard Readiness Center
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LIST OF ACRONYMS

<u>Acronym</u>	<u>Definition</u>
AGE	Aerospace Ground Equipment
ANG	Air National Guard
ANG/CEVR	Air National Guard/Civil Engineering Environmental Restoration Group
ANGS	Air National Guard Station
AOC	Area of concern
ARAR	Applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
bgs	Below ground surface
Boeing	The Boeing Company
CCSQ	Combat Communications Squadron
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLARC II	Model Toxics Control Act Cleanup Levels and Risk Calculations
COC	Contaminant of concern
DERP	Defense Environmental Restoration Program
EDR	Environmental Data Resources, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
ERM	Environmental Resources Management
FS	Feasibility Study
GPR	Ground penetrating radar
IDW	Investigation-derived waste
IRP	Installation Restoration Program
LTM	Long-term monitoring
MCLs	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
µg/kg	Micrograms per kilogram
µg/l	Micrograms per liter
mg/kg	Milligrams per kilogram
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
OpTech	Operational Technologies Corporation
OSHA	Occupational Safety and Health Act

LIST OF ACRONYMS

<u>Acronym</u>	<u>Definition</u>
PA	Preliminary Assessment
PA/SI	Preliminary Assessment/Site Inspection
PCE	Tetrachloroethylene
pCi/g	PicoCuries per gram
PID	Photoionization detector
PREE/CA	Presumptive Remedy Engineering Evaluation/Cost Analysis
PSG	Project screening goal
PVC	Polyvinyl chloride
QA	Quality assurance
QA/QC	Quality assurance/quality control
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Investigation
SMCL	Secondary Maximum Contaminant Level
SSHP	Sitewide Safety and Health Plan
SVOC	Semivolatile organic compound
TCE	Trichloroethylene
TPH	Total petroleum hydrocarbons
TSD	Treatment, storage, or disposal
TVH	Total volatile hydrocarbons
UCL	Upper confidence limit
USEPA	United States Environmental Protection Agency
VOA	Volatile organics analysis
VOC	Volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology

SECTION 1.0

INTRODUCTION

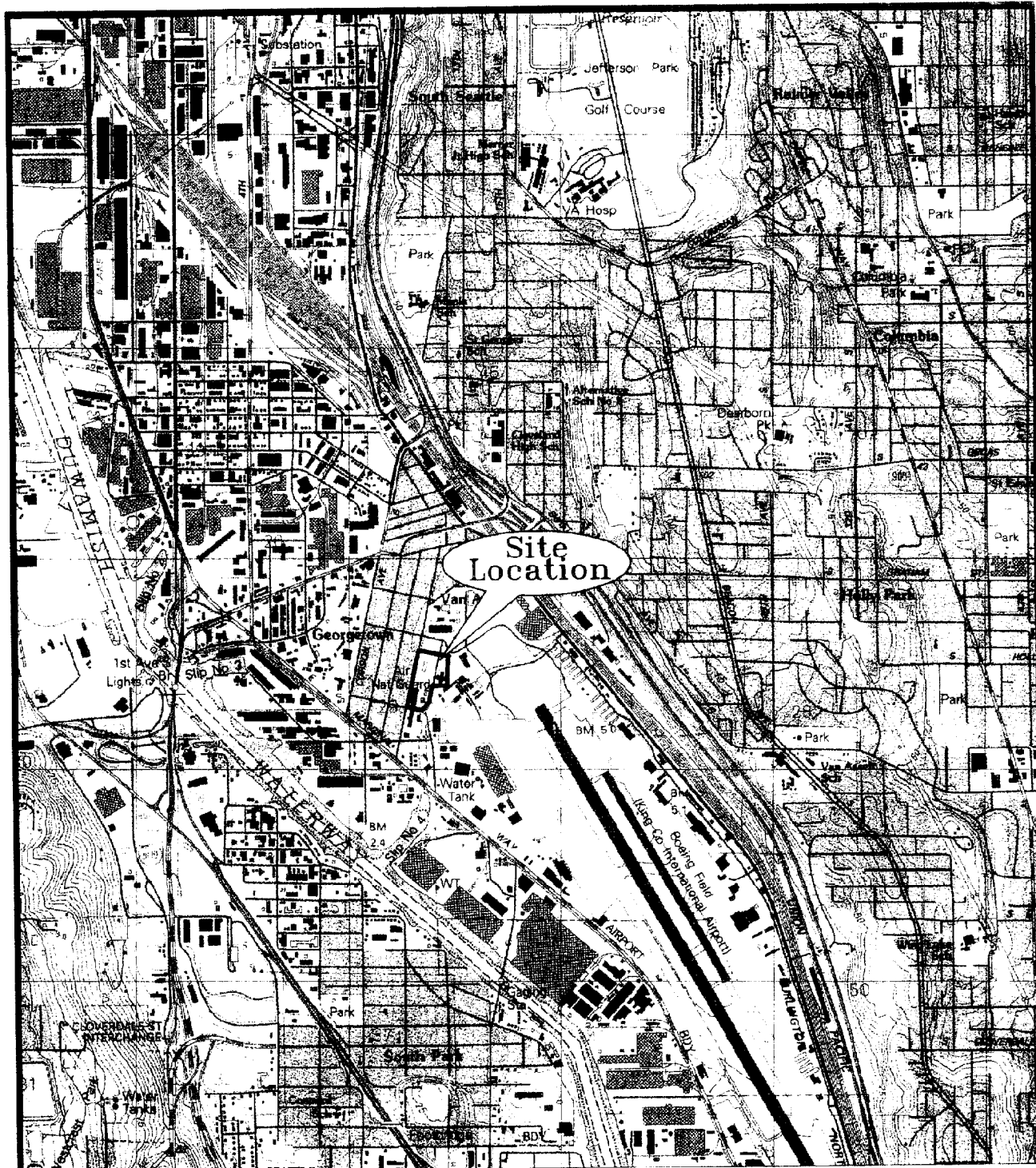
Environmental Resources Management (ERM) has prepared this Phase II Remedial Investigation/Feasibility Study (RI/FS) Work Plan in support of the planned Phase II Remedial Investigation (RI) at the 143rd Combat Communications Squadron (CCSQ), Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington (Figure 1-1). This study is part of the Installation Restoration Program (IRP) of the Air National Guard (ANG). The work is being performed under contract DAHA90-94-0014 between ERM and the National Guard Bureau, Departments of the Army and the Air Force. The Air National Guard/Civil Engineering Environmental Restoration Group (ANG/CEVR), IRP Branch, is providing technical and project management oversight of the work.

A Phase I RI was completed at the site in 1997. The results of the Phase I RI are reported in ERM (1998). The purpose of this Phase II RI/FS Work Plan is to describe the elements and procedures of the planned Phase II RI. The Feasibility Study (FS) component of this Work Plan (Sections 13.0 and 15.0) is essentially unchanged from the RI/FS Work Plan prepared for the Phase I RI (ERM, 1996).

This Phase II RI/FS Work Plan follows the recommended ANG/CEVR format and contains the basic contents suggested in the United States Environmental Protection Agency (USEPA) document *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988).

1.1 Project Objectives and Scope

This section summarizes the objectives and scope of work for the Phase II RI and FS activities at the Seattle ANGS.



0 2000
FEET



From USGS 7.5 Minute
Topographic Map Series
Seattle South, Washington

FIGURE 1-1

LOCATION MAP OF SEATTLE
AIR NATIONAL GUARD STATION
SEATTLE, WASHINGTON
143rd CCSQ, Seattle ANG
Seattle, Washington



S:\CAD\DWGS\6032\41\60324115

1.1.1 Objectives and Scope of the Phase II Remedial Investigation

The purpose of the Seattle ANGS Phase II RI is to supplement the Phase I RI completed in 1997 (ERM, 1998) with additional data needed to provide the necessary site characterization for an FS. Specifically, the objectives of the Phase II RI are to:

- Provide additional data to assist in defining the source and extent of soil and groundwater contamination at the Station;
- Refine the understanding of the pathways of contaminant migration;
- Determine compliance of the contaminants of potential concern (COPCs) identified in soil and groundwater with applicable or relevant and appropriate requirements (ARARs); and
- Assess the potential threats to human health associated with the contaminants of concern (COCs) identified in soil and groundwater.

The Seattle ANGS Phase II RI will provide the supplementary data needed for an accurate and representative characterization of soil and groundwater contamination at the Station. The Phase II RI will include the collection and analysis of soil, soil vapor, and groundwater samples using Geoprobe/HydroPunch direct-push techniques, installation of groundwater monitoring wells, and quarterly sampling of the new and existing monitoring wells at the Station for 1 year. Information obtained during the Phase II investigation will be used along with the results of the Phase I RI during development of the FS, as the scientific basis for identifying and selecting the most appropriate remedial alternatives for the Station.

1.1.2 Objectives and Scope of the Feasibility Study

The objectives and scope of the FS are to:

- Identify, screen, develop, and evaluate remedial alternatives for addressing soil and groundwater contamination at the Station that may pose a threat to human health or the environment; and
- Recommend the most cost-effective remedial alternatives that adequately protect human health, welfare, and the environment.

The evaluation of remedial alternatives will include an analysis of technical feasibility, cost, remediation timeframe, and the degree to which regulatory treatment preferences are satisfied. The FS will be conducted in accordance with State and Federal guidelines.

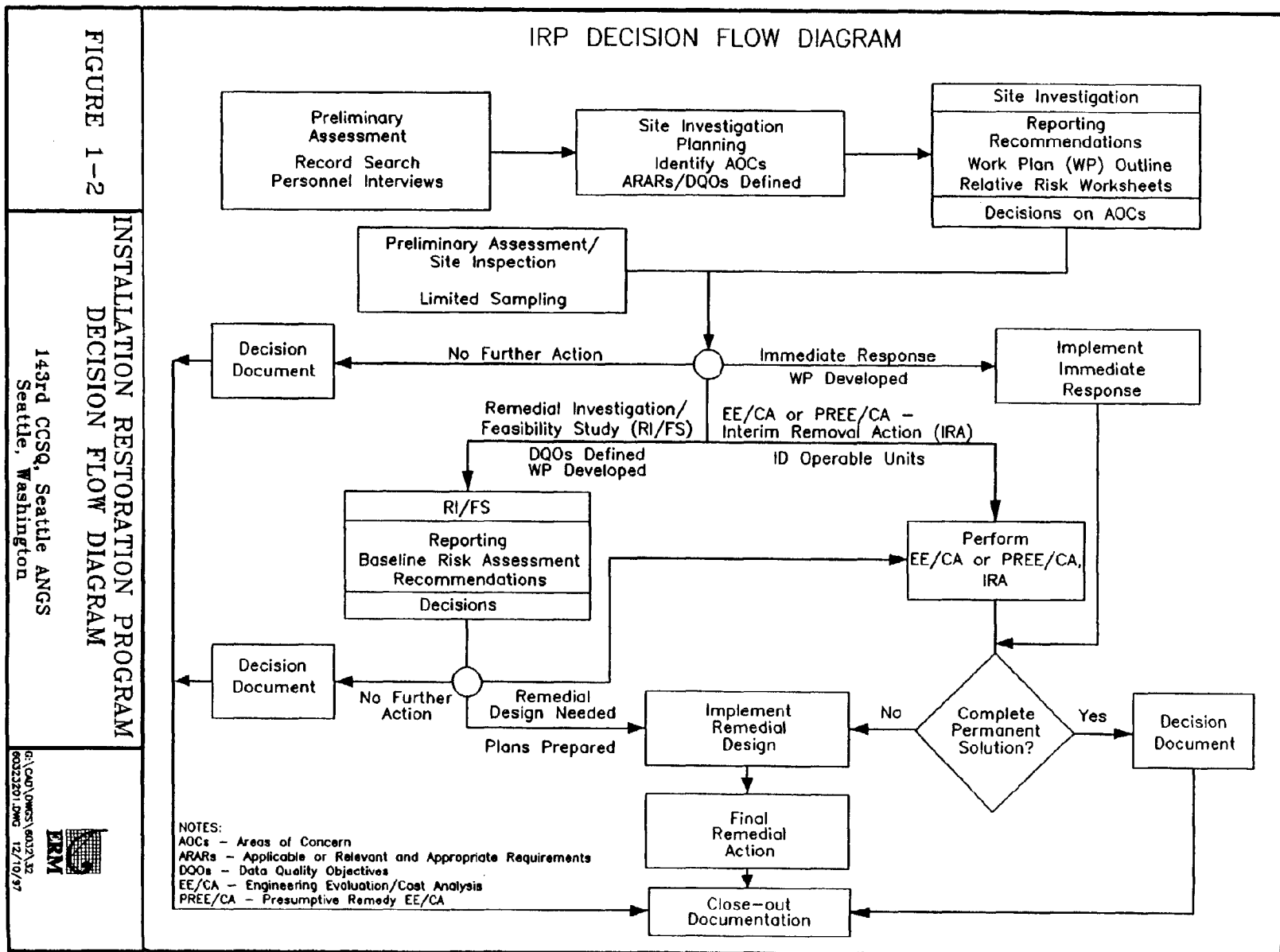
1.2 Installation Restoration Program (IRP) Description

The Defense Environmental Restoration Program (DERP) was established in 1984 to promote and coordinate efforts for the evaluation and cleanup of contamination at Department of Defense installations. On January 23, 1987, Presidential Executive Order 12580 was issued which assigned the responsibility for carrying out DERP within the overall framework of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) to the Secretary of Defense. The IRP was established under DERP to identify, investigate, and remediate contamination at installations. The IRP focuses on cleanup of contamination associated with past Department of Defense activities to ensure that threats to public health are eliminated and to restore natural resources for future use.

The IRP is divided into several phases as illustrated on Figure 1-2. These phases are defined and described in the following subsections.

1.2.1 Preliminary Assessment

The Preliminary Assessment (PA) consists of personnel interviews and a record search designed to identify and evaluate past disposal and/or spill sites that might pose a potential or actual hazard to public health, public welfare, or the environment. Previously undocumented information is obtained through the interviews. The record search focuses on obtaining useful information from: aerial photographs; installation plans; facility inventory documents; lists of hazardous materials used; subcontractor reports; correspondence; Material Safety Data Sheets; federal/state agency scientific reports on endangered and threatened species and critical habitats; documents from local government offices; and numerous standard reference sources.



1.2.2 Site Inspection

The purpose of the Site Inspection (SI) is to perform limited sampling and other field activities to confirm the presence or absence of contamination at potential areas of concern (AOCs) identified during the PA. This may include, for example, geophysical surveys, field screening, soil sampling, and limited groundwater sampling for suspected contaminants. The SI may be conducted in conjunction with the PA. Data collected during the PA and SI may be sufficient to reach a decision point for a site, such as no further IRP action is warranted, prompt removal of contaminants is necessary, or further IRP work is required.

1.2.3 Site Investigation

Like the SI, the Site Investigation consists of field activities designed to confirm the presence or absence of contamination at potential AOCs identified during the PA. However, the Site Investigation typically includes more extensive sampling and evaluation of groundwater than the SI. An additional objective of the Site Investigation is to determine potential risks to human health and the environment.

The activities undertaken during the Site Investigation generally fall into three categories: screening, confirmation, and optional activities. Screening activities are conducted to gather additional preliminary data not obtained during the PA. Confirmation activities include specific media sampling and laboratory analysis to confirm either the presence or the absence of contamination, chemical concentrations, and the potential for migration of contaminants. Information obtained during the subsurface investigation is utilized to define AOCs from among the potential AOCs identified during the PA. Site hydrology, geology, and soil properties are also characterized during the Site Investigation. Additional data may be needed to reach a decision point for a site. Optional activities may be conducted to obtain the additional data needed.

The general approach of the Site Investigation is to sequence the field activities so that data are acquired and used as the field investigation progresses. This is done to determine the presence or absence of contamination in a relatively short time period, optimize data collection and data quality, and minimize costs.

1.2.4 Remedial Investigation

The objectives of the RI are to determine the nature and extent of contamination at a site, determine the nature and extent of potential threats to human health and the environment, and provide a basis for determining the types of response actions to be considered (Decision Document, FS, Remedial Design [RD], or Remedial Action [RA]).

The RI consists of field activities designed to quantify the potential contaminant, the extent of the contamination, and the pathways of contaminant migration. Field activities may include the installation of soil borings and/or monitoring wells and the collection and analysis of water, soil, and/or sediment samples. Careful documentation and quality control procedures are implemented during RI field activities in accordance with CERCLA/SARA guidelines which ensure the validity of data.

Hydrogeologic studies are conducted to determine the underlying strata, groundwater flow rates, and direction of contaminant migration.

A baseline risk assessment, which provides an evaluation of the potential threat to human health, is conducted prior to implementing any RA. The baseline risk assessment provides the basis for determining whether an RA may be necessary to mitigate endangerment to public health.

The findings from the RI will result in the selection of one of the following options:

- No Further Action: The results of investigations do not indicate harmful concentrations of chemicals that pose a significant threat to human health or the environment. Therefore, no further IRP action is warranted and a decision document will be prepared to close the site.
- Long-Term Monitoring (LTM): The results of investigations do not indicate the presence of sufficient contamination to justify costly RA. LTM may be recommended to detect the possibility of future problems.
- FS: The results of investigations confirm the presence of contamination that may pose a threat to human health and/or the environment, and some sort of RA is indicated.

1.2.5 Feasibility Study

Based on results of the RI, the baseline risk assessment, and a review of state and federal regulatory requirements, an FS may be conducted to develop, screen, and evaluate alternatives for remediation of groundwater and/or soil contamination at the site. The overall objectives of the FS include providing information necessary for remedial alternative development and evaluating information to support selection of a remedy that is protective of human health and the environment; considers ARARs; satisfies the preference for treatment that significantly and permanently reduces toxicity, mobility, or volume of hazardous constituents as a principal element; and is cost-effective.

Activities associated with the FS include the following:

- Identification of applicable remediation technologies/RAs;
- Preliminary screening of technologies;
- Development of remedial alternatives;
- Detailed analysis of alternatives;
- Comparative analysis of alternatives; and
- Completion of an FS report.

The end result of the FS is the selection of the most appropriate remedial alternative with concurrence by state and/or federal regulatory agencies.

1.2.6 Engineering Evaluation/Cost Analysis

At any time during the course of an IRP project, an Engineering Evaluation/Cost Analysis (EE/CA) can be implemented to evaluate remedial solutions for contamination. An EE/CA can be completed for all non-time-critical removal actions that are not addressed by an FS. In general, an EE/CA is similar to an RI/FS but is less comprehensive because of the presumption of an RA. An EE/CA is usually completed as a parallel effort to an RI/FS. The overall objectives of the EE/CA include satisfying environmental review and administrative requirements for removal actions; providing a framework for evaluating and selecting alternative technologies; satisfying the preference for a treatment that significantly and permanently reduces toxicity, mobility, or volume of

hazardous constituents as a principal element; and maximizing cost-effectiveness.

The goals of the EE/CA are to:

- Develop an Approval Memorandum;
- Identify removal action objectives;
- Identify and analyze removal action alternatives;
- Compare removal action alternatives; and
- Recommend removal action alternatives in an Action Memorandum.

The end result of the EE/CA is the selection of the most appropriate removal action with concurrence by state or federal regulatory agencies.

1.2.7 Presumptive Remedy Engineering Evaluation/Cost Analysis

A Presumptive Remedy Engineering Evaluation/Cost Analysis (PREE/CA) may be performed if the results of investigations indicate the presence of sufficient contamination to justify an RA prior to completion of an FS, and the technology required for the RA is evident. A PREE/CA may be recommended to evaluate the effectiveness and costs associated with the presumptive RAs.

1.2.8 Remedial Design

The RD involves development and approval of the engineering designs required to implement the selected remedial alternative identified in the FS.

1.2.9 Remedial Action

The RA is the actual implementation of the remedial alternative. It refers to the accomplishment of measures to eliminate the hazard or, at a minimum, reduce it to an acceptable limit. Covering a landfill with an impermeable cap, pumping and treating contaminated groundwater, installing a new water distribution system, and in situ biodegradation of contaminated soils are examples of remedial measures that might be selected. In some cases, after the RAs have been completed, an LTM

system may be installed as a precautionary measure to detect contaminant migration or to document the efficiency of remediation.

1.2.10 Immediate Action Alternatives

At any point, it may be determined that a site poses an immediate threat to public health or the environment, thus necessitating prompt removal of the contaminants. Immediate action, such as limiting access to the site, capping or removing contaminated soils, and/or providing an alternative water supply may suffice as effective control measures. Sites requiring immediate removal action maintain IRP status in order to determine the need for additional remedial planning or LTM. Removal measures or other appropriate RAs may be implemented during any phase of an IRP project.

1.3 General Investigation Approach

Forty soil vapor sampling points, 20 Geoprobe/HydroPunch soil and groundwater sampling points, and five groundwater monitoring wells will be installed during the Phase II RI. The soil vapor survey will be the first field task conducted; the results will be used to guide the selection of the Geoprobe/HydroPunch sampling locations. Similarly, the Geoprobe/HydroPunch sampling results will be used to guide the selection of the monitoring wells locations.

Quarterly groundwater monitoring will be conducted for 1 year to assess compliance with ARARs and trends in concentrations of volatile organic compounds (VOCs) in groundwater. The quarterly groundwater monitoring events will include each new and existing monitoring well at the Station (13 wells total).

1.4 Work Plan Structure

This Phase II RI/FS Work Plan provides a description of the activities for the RI/FS and is organized into 17 sections and three appendices. The contents of the sections are as follows:

- Section 1.0 provides general introductory information for this Work Plan.

- Section 2.0 describes the project management approach for the RI/FS.
- Section 3.0 provides background information for the Seattle ANG.
- Section 4.0 describes the environmental setting for the vicinity of the Seattle ANG.
- Section 5.0 describes the permits required to perform the Phase II RI field activities.
- Section 6.0 outlines the Phase II RI investigation approach.
- Section 7.0 describes field investigation methods and procedures.
- Section 8.0 describes sample collection procedures.
- Section 9.0 describes investigation-derived waste management.
- Section 10.0 describes ARARs and project screening goals (PSGs).
- Section 11.0 describes the objectives and scope of the contaminant fate and transport evaluation.
- Section 12.0 describes the objectives and scope of the baseline risk assessment.
- Section 13.0 discusses the key elements of the FS.
- Section 14.0 describes the purpose and format of the RI portion of the RI/FS report.
- Section 15.0 describes the purpose and format of the FS portion of the RI/FS report.
- Section 16.0 outlines the project schedule and deliverables.
- Section 17.0 lists the references cited in this Work Plan.

The following appendices are included in this Work Plan:

- Appendix A contains the Sitewide Safety and Health Plan (SSHP).
- Appendix B contains the Quality Assurance Project Plan (QAPP).
- Appendix C contains the Table of Contents for the Phase I RI report and a sample outline for the FS portion of the RI/FS report.

SECTION 2.0

PROJECT MANAGEMENT APPROACH

The successful execution of this Phase II RI/FS depends on a strong, qualified project team. Accordingly, ERM will utilize an experienced team of professionals who have previously performed similar work at other investigation sites. The project team will be selected by the ERM Program Manager and the names and qualifications of the project team will be submitted to the ANG Project Manager upon request.

2.1 Project Management Organization

The project will be managed and executed by personnel who will ensure that the objectives of the RI/FS are met. Figure 2-1 provides an organization chart for this project. The chart includes the names of key management personnel assigned to the Seattle ANGS Phase II RI/FS project.

The drilling, analytical services, and surveying support will be provided by experienced subcontractor firms that possess the required permits, licenses, and accreditations necessary to work in the State of Washington.

ERM's project team will consist of the key positions described below.

Program Manager: Responsible for the overall execution of the project and for maintaining an open line of communication with the ANG/CEVR and the ANG Environmental Coordinator.

Project Manager: Supervises the project team, provides technical direction and interface with the ANG Project Manager and ANG Environmental Coordinator, coordinates subcontractor support, and manages project schedule and budget.

Site Manager: Directly supervises the on-site field investigation activities and project team, and provides technical direction and interface with the Project Manager.

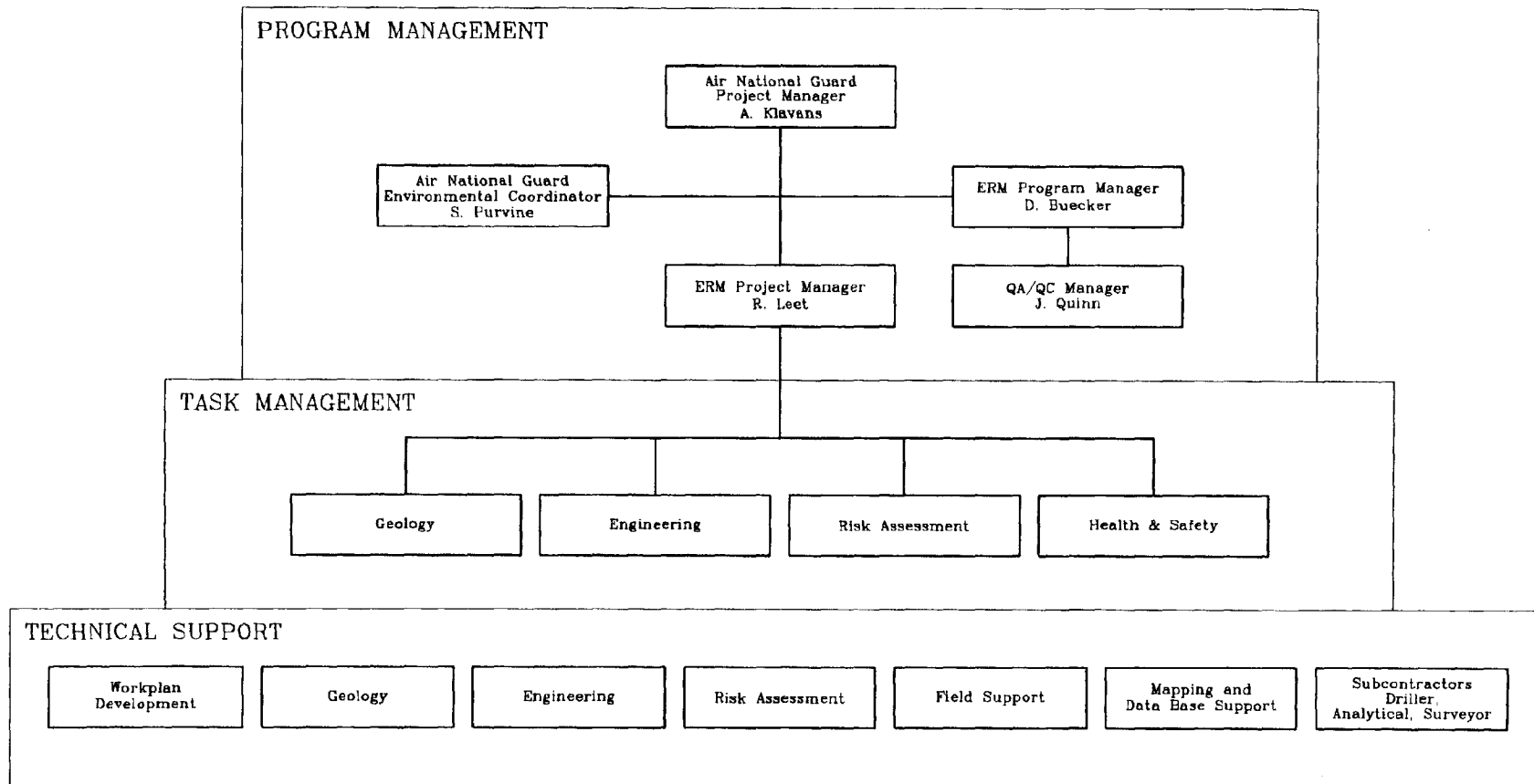


FIGURE 2-1

SEATTLE ANG'S PHASE II
RI/FS PROJECT ORGANIZATION143rd CCSQ, Seattle ANG'S
Seattle, Washington

Quality Assurance/Quality Control (QA/QC) Manager: Responsible for establishing standardized quality assurance (QA) procedures for this project and for ensuring that effective procedures and controls are implemented to achieve project quality goals and adherence to contract requirements.

Site Safety and Health Officer: Responsible for ensuring that physical and chemical hazards are appropriately mitigated through effective execution of the SSHP.

Project Scientists and Engineers: Includes qualified geologists, chemists, toxicologists, and engineers.

2.2 Project Procedures

An open line of communication will be maintained between the Project Manager and the project team to ensure that the project objectives are met. Sampling and other field activities will be carried out in accordance with this Work Plan. The Phase II RI/FS will be executed according to the project schedule included in Section 16.0 of this Work Plan.

2.3 Quality Management

The QA/QC Manager will be responsible for ensuring that established QA/QC procedures are followed. Immediate corrective actions will be taken at any time they are deemed necessary. QA/QC procedures will be directed in accordance with the QAPP contained in Appendix B.

2.4 Subcontract Management

ERM is responsible for the performance of all work under this contract delivery order, including the work of subcontractors. ERM will hire subcontractors for drilling, analytical services, and surveying support. The Project Manager and Site Manager will maintain oversight of the subcontractors' completion of specified tasks with respect to technical performance, quality, and adherence to cost and schedule. In addition, ERM will ensure that subcontractor activities comply with the QAPP and SSHP prepared for this RI/FS.

SECTION 3.0

INSTALLATION BACKGROUND INFORMATION

This section describes the Seattle ANGS facility and the associated IRP site, and summarizes the waste disposal history at the facility, the results of regulatory records reviews, and previous investigations at the Station. Information presented in this section was derived from the Preliminary Assessment/Site Inspection (PA/SI) report (OpTech, 1995) and the Phase I RI report (ERM, 1997).

3.1 Installation Description

The Seattle ANGS is at 6736 Ellis Avenue South in Seattle, Washington. The Station occupies approximately 7.5 acres of land in the northwest portion of the King County International Airport (Boeing Field; Figure 1-1 and Figure 3-1). The facility employs 129 personnel, of which 25 are full-time employees.

3.1.1 Station History

The Seattle ANGS was built during World War II by the War Department and was used by the United States Army Air Corps as the "Aircraft Factory School" during the war. In 1948 the property was given to King County as surplus property and was subsequently leased to the Washington Air National Guard.

On April 21, 1948, the 143rd Aircraft Control and Warning Squadron was established. From May 1951 to February 1953, the 143rd was activated for recruitment purposes. During this period of time the unit had two C-47 aircraft. In 1960 the name of the unit was formally changed to the 143rd Communications Squadron Tributary Teams. In 1969 and 1988 the name of the unit was again changed becoming the 143rd Mobile Communications Squadron and the 143rd CCSQ, respectively. The current mission of the 143rd CCSQ is to provide mobile communication equipment and support for airports and airfields.

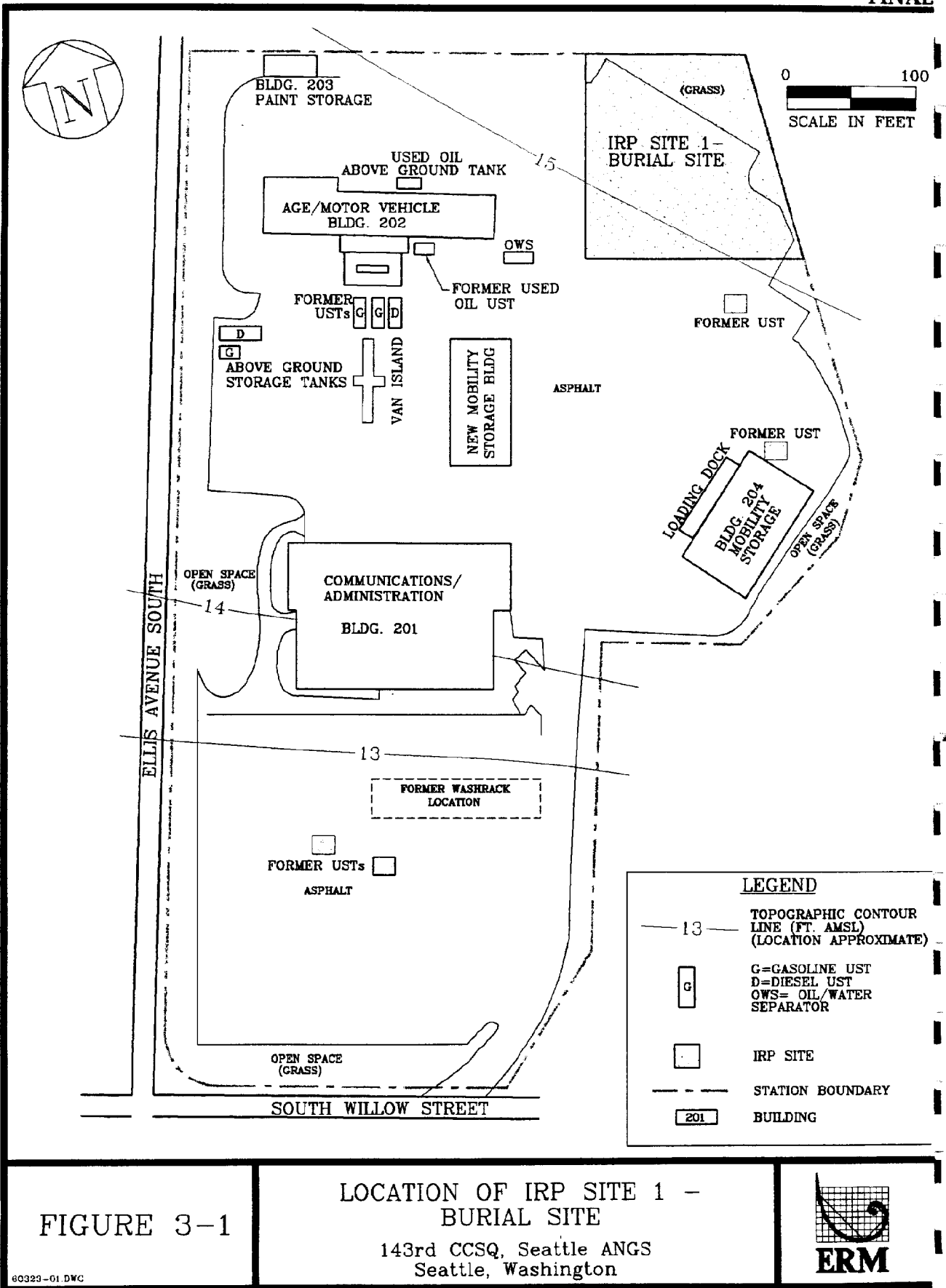


FIGURE 3-1

LOCATION OF IRP SITE 1 - BURIAL SITE

143rd CCSQ, Seattle ANG
 Seattle, Washington



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In 1948 the Station consisted of 17 acres of land, including an aircraft parking ramp, leased from King County. At that time the property contained 15 buildings, all of which were subsequently demolished. In 1951 a new property lease decreased the size of the Station from 17 acres to its present size of 7.5 acres. Buildings were constructed for headquarters, a mess hall, warehouses, and vehicle service requirements. In 1980 the National Guard Bureau approved and Congress funded the replacement of all buildings. The buildings were completed in 1984, with the exception of Building 204 (Mobility Storage), which was completed in 1988, and the new Mobility Storage Building, which was completed in 1998. The Seattle ANGS currently consists of 7.5 acres and five buildings (Figure 3-1). The Seattle ANGS property is leased from King County by the United States Air Force, who in turn licenses the property to the Washington State Military Department for ANG use.

3.1.2 Adjacent Land Use

Land use adjacent to the Seattle ANGS is shown on Figure 3-2. Adjacent properties to the north, south, and east of the Station are zoned for general industrial use, are currently used for industrial purposes, and have a history of industrial use. The properties directly south and east of the Station are owned by The Boeing Company (Boeing) or leased by Boeing from King County. The property immediately north of the Station is utilized by several trucking firms and a Washington State Motor Pool auto maintenance facility, while the area west of the Station, across Ellis Avenue South, consists of residential properties.

3.1.3 IRP Site 1 - Burial Site Description

As shown on Figure 3-1, IRP Site 1 (the IRP site) is located in the northeast corner of the Seattle ANGS. The site is approximately 175 feet long and an average of 175 feet wide. The north and east sides of the IRP site are bounded by a 6-foot-high fence. With the exception of the grass-covered northeast corner, the site is covered with asphalt and is used as a vehicle parking area.

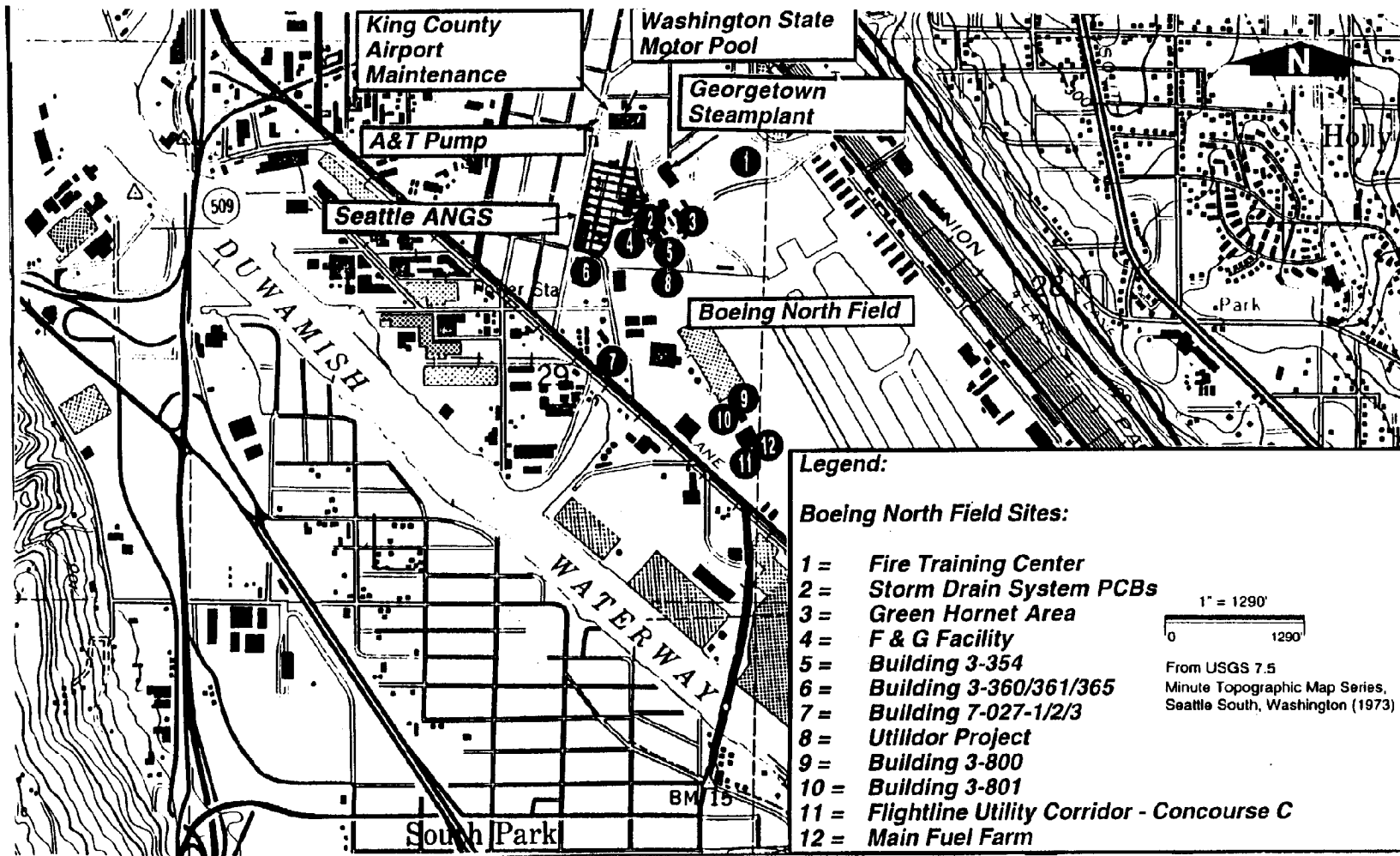


FIGURE 3-2

ADJACENT LAND USE AND
SITES OF ENVIRONMENTAL CONCERN

143rd CCSQ, Seattle ANG
Seattle, Washington



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3.2 Waste Disposal History

This section summarizes the results of the PA/SI regarding hazardous materials/wastes generated, historical and current disposal practices, and past environmental incidents and problems at the Seattle ANGS.

The information presented in the PA/SI report is based on interviews with past and present Station employees, a review of Station records and other pertinent information, and a field survey.

3.2.1 Wastes Generated by Station Operations

A variety of wastes were burned and/or buried at the IRP site from the early 1950s through 1968. The wastes most likely disposed of at the IRP site include radio tubes, solvents, waste motor oils, kerosene, batteries, brake fluid, spray paints, paint thinners or removers, methyl ethyl ketone, xylene, and naptha. These wastes were generated by the Aerospace Ground Equipment (AGE)/Motor Vehicle Maintenance, Power Production, and Communication/Administration Buildings.

3.2.2 Disposal Practices at the Station

Historical disposal practices at the Seattle ANGS included land disposal within the IRP site and off-site disposal. Presently, discarded hazardous materials and hazardous wastes are collected and disposed of either by an appropriately licensed contractor or through the Defense Reutilization and Marketing Office at Fort Lewis, Washington.

3.2.3 Past Environmental Incidents and Problems

Small amounts of hazardous materials are reported to have been spilled or released to the environment at the Station in the past. The PA/SI identified the IRP site as the only potentially contaminated disposal site at the Station. Identification of this site was based on interviews with past and present employees, an analysis of pertinent information and Station records, and a field survey.

3.3 Regulatory Records Review

The PA/SI identified several sites on properties adjacent to the Seattle ANGS with a history of environmental contamination or environmental incidents. Environmental conditions at nearby properties were further evaluated during preparation of the Phase I RI/FS Work Plan. The results of this evaluation are summarized below.

An Environmental Data Resources, Inc. (EDR) summary report was prepared on the location and status of sites of environmental significance within a 1 mile radius of the Seattle ANGS. The EDR database search identified 19 sites within a 1 mile radius of the Station that appear on the Washington Department of Ecology's (WDOE's) Confirmed and Suspected Contaminated Sites List. The EDR database search also identified 14 leaking underground storage tank sites within a 1/2 mile radius of the Station. In addition, one sensitive receptor category, a daycare center, was identified within a 1/4 mile radius of the Station.

The second phase of the regulatory records review included a review of WDOE's file records regarding selected sites of environmental concern. These sites include the following:

- Boeing North Field (12 sites), Ellis Avenue South & Marginal Way;
- King County Airport Maintenance, 6518 Ellis Avenue South;
- Washington State Motor Pool, 6650 Ellis Avenue South;
- Seattle City Light - Georgetown Steamplant, 1131 South Elizabeth Street; and
- A & T Pump, 6525 Ellis Avenue South.

The locations of these sites relative to the Seattle ANGS are shown on Figure 3-2. Details regarding previous investigations and documented contamination at these sites are presented in the Phase I RI/FS Work Plan (ERM, 1996). Based on the WDOE file review, none of the environmental impacts at these sites appear to represent a potential source of significant contamination on the Seattle ANGS property.

3.4 Previous Investigations

This section summarizes previous investigations conducted as part of the IRP at the Seattle ANGS.

3.4.1 Preliminary Assessment

A Draft PA was completed by the ANG in December 1993. The PA focused on past and present generation, use, handling, and disposal practices of hazardous waste and materials at the Seattle ANGS. Based on the results of the PA, the IRP site was identified as being potentially contaminated with hazardous materials/hazardous waste and was recommended for further IRP investigation.

3.4.2 Preliminary Assessment/Site Inspection

A PA/SI was conducted at the Station in 1994 by OpTech (OpTech, 1995). This section summarizes the scope of work and results of the PA/SI field activities.

3.4.2.1 Scope of Work

The purpose of the PA/SI was to identify AOCs and to confirm the presence or absence of soil and groundwater contamination associated with past hazardous material and hazardous waste handling and disposal practices at the Station. In addition to the identification of AOCs, the scope of the PA/SI included defining the nature of known or suspected releases at the AOCs; identifying potential receptors; confirming the presence or absence of soil and groundwater contamination; describing the geologic conditions of the study area; and defining hydrogeologic conditions such as groundwater flow direction. The PA/SI scope of work did not include determination of the source or extent of contamination at the IRP site or assessment of possible threats to human health and the environment.

Field work for the PA/SI was performed in June and July 1994. Screening activities at the IRP site included a ground penetrating radar (GPR) survey, a magnetometer survey, and a shallow soil vapor survey. Confirmation activities at the IRP site included collection of subsurface soil samples from soil borings and monitoring well borings, and installation and sampling of groundwater monitoring wells.

3.4.2.2 Geophysical Investigation Results

The GPR survey revealed an anomalous soil horizon or disturbed soil area in the southwest portion of the IRP site, with an upper interface approximately 4.5 to 6.0 feet below ground surface (bgs). The origin of this anomalous soil material was interpreted as being associated either with the filling-in of a former Duwamish River meander or with the historical burial or burning activities at the IRP site. Magnetometer data collected at the IRP site did not indicate any significant metal masses buried within the area of disturbed soil (OpTech, 1995).

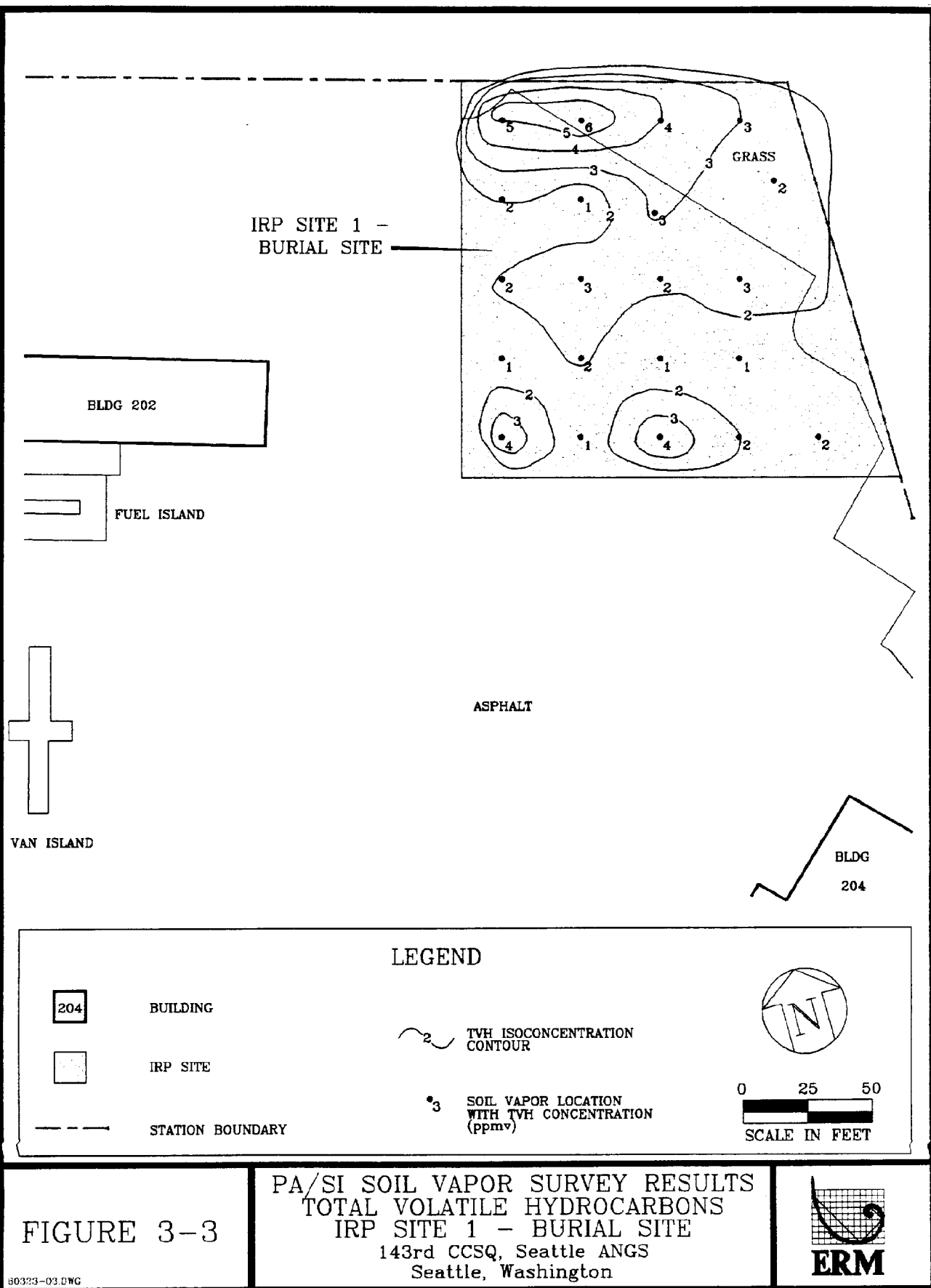
3.4.2.3 Soil Vapor Survey Results

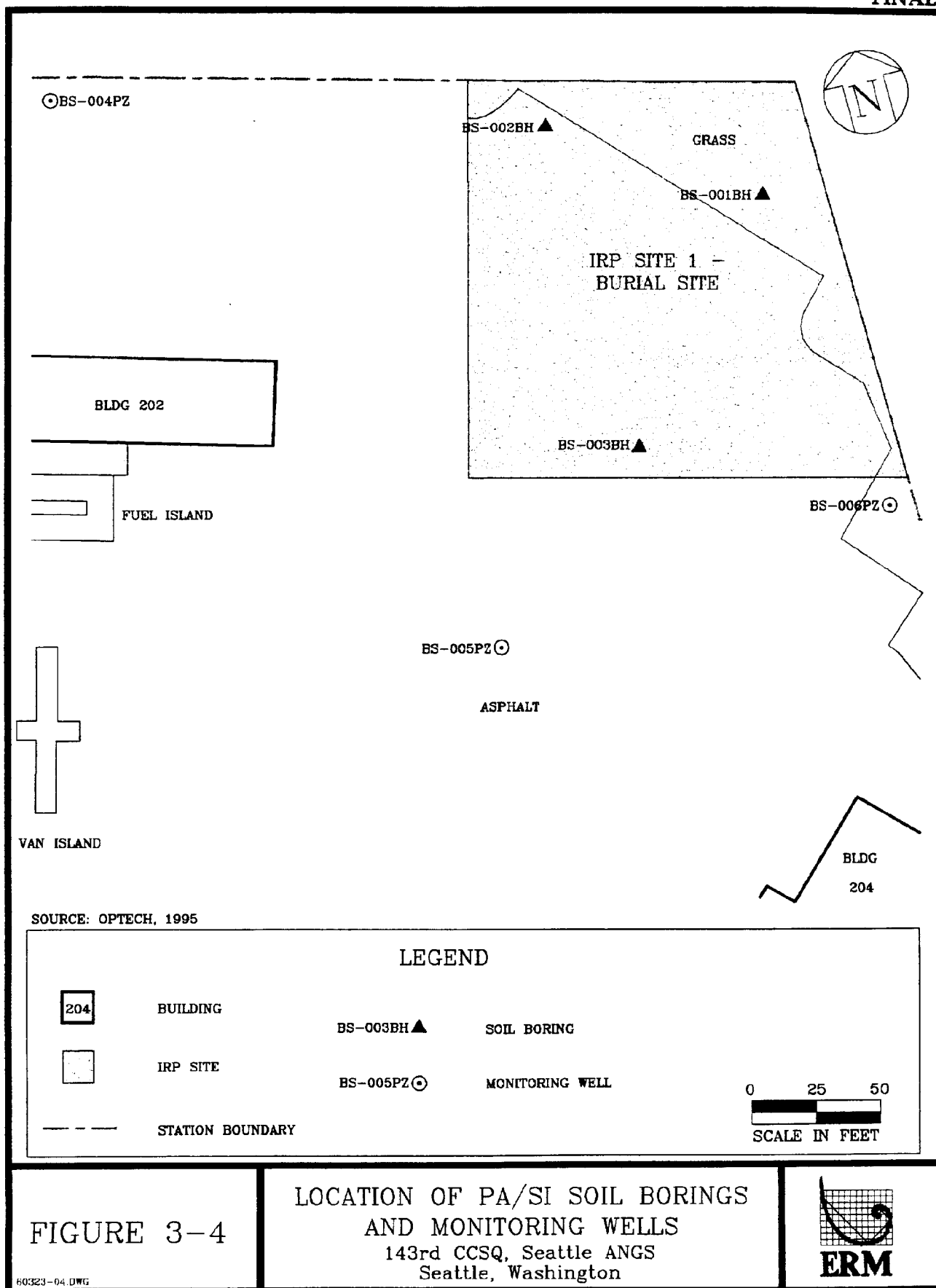
Soil vapor samples were collected within 5 feet of the ground surface from 21 locations at the IRP site. The samples were analyzed for total volatile hydrocarbons (TVH). Local areas of slightly elevated TVH concentrations were identified at the IRP site (Figure 3-3). The results of the soil vapor survey were used to determine the final placement of soil borings.

3.4.2.4 Results of Soil and Groundwater Analyses

The PA/SI sampling locations at IRP Site 1 are shown on Figure 3-4. The analytical results for soil and groundwater samples collected during the PA/SI are summarized on Tables 3-1 and 3-2, respectively. For comparison, project screening goals (PSGs) developed during the Phase I RI are also shown on Tables 3-1 and 3-2. The PSGs were developed from Washington State Model Toxics Control Act (MTCA) Method A Cleanup Levels, MTCA Method B Formula Values, regional and site-specific background concentrations, and/or Federal Maximum Contaminant Levels (MCLs) for drinking water. PSGs are discussed further in Section 10.0 of this Work Plan.

One semivolatile organic compound (SVOC), di-n-butylphthalate, was detected in all but one of the soil samples collected during the PA/SI. The presence of di-n-butylphthalate was attributed to possible laboratory contamination of the samples. Total petroleum hydrocarbon (TPH) contamination was detected at a concentration exceeding the associated MTCA Method A Cleanup Level in one soil sample. Beryllium concentrations detected in all of the soil samples exceeded the MTCA Method B Cancer Formula Value. In addition, gross alpha and gross beta radiation were detected in approximately half of the soil samples collected. No regulatory standards (maximum acceptable concentrations) have been established for gross alpha or gross beta radiation in soil.





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TABLE 3-1

Summary of PA/SI Soil Chemical Quality Data
143rd CCSQ, Seattle ANG, Seattle, Washington
Source: Optech, 1995

Location	Sample Depth (ft-bgs)	Volatile Organic Compounds (USEPA Method 8240) (µg/kg)	Semivolatile Organic Compounds (USEPA Method 8270) (µg/kg) di-n-butyl phthalate	Total Petroleum Hydrocarbons (WTPH-D, G) (mg/kg)	Polychlorinated Biphenyls (USEPA Method 8080) (µg/kg)	Radionuclides (USEPA Method 9310) (pCi/g)		Trace Metals (mg/kg)													
						Gross Alpha	Gross Beta	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn	
Background (BS-004FZ)	8.5 - 10.0	ND	2,240	ND	ND	0 ± 17	0 ± 32	ND	2	1.2	1.6	10	40	34	ND	13	ND	ND	0.056	25	
BS-001BH	1.0 - 2.5	ND	1,750	ND	ND	4 ± 27	2 ± 35	ND	0.33	1	1.6	11	130	28	ND	14	0.053	0.18	0.038	19	
	5.5 - 7.0	ND	1,680	ND	ND	0 ± 18	4 ± 36	ND	1.6	0.82	1.1	11	16	16	ND	5.8	ND	ND	0.03	8.6	
	8.5 - 10.0	ND	1,590	ND	ND	0 ± 20	0 ± 24	ND	0.033	0.29	0.66	7.9	9.3	9.7	ND	5.6	ND	ND	ND	14	
BS-002BH	1.0 - 2.5	ND	1,640	ND	ND	2 ± 25	3 ± 37	ND	2.7	0.87	1.3	10	23	28	ND	9.3	ND	ND	0.024	31	
	5.5 - 7.0	ND	900	ND	ND	2 ± 25	0 ± 36	ND	1.1	0.49	0.92	14	23	15	ND	6.2	ND	ND	0.054	16	
	8.5 - 10.0	ND	1,960	ND	ND	2 ± 25	0 ± 34	ND	0.63	0.34	0.75	9.3	7.5	10	ND	7.2	ND	ND	ND	20	
BS-003BH	2.0 - 3.5	ND	ND	780*	ND	2 ± 20	2 ± 30	ND	4.1	1	1.3	11	20	27	ND	8.6	ND	ND	0.053	19	
	5.5 - 7.0	ND	744	160*	ND	0 ± 21	0 ± 34	ND	20	1.1	1.5	15	33	62	ND	14	ND	0.042	0.093	40	
	8.5 - 10.0	ND	1,750	ND	ND	0 ± 21	0 ± 34	ND	3.7	0.58	1	12	14	29	ND	8.3	0.11	ND	ND	20	
RI Project Screening Goal					100/200 (1)	9.96	16.1		20				2	100	2,960	250		1,600	400		24,000
ARAR			8,000,000 (a)							0.233 (b)								400 (a)	5.6 (a)		
Natural Background (c)						7.3	0.61	0.77	48.15	36.36	16.83				38.19	0.78	0.61	NA		85.06	

PA/SI = Preliminary Assessment/Site Inspection

RI = Remedial Investigation

USEPA = United States Environmental Protection Agency

ft-bgs = Feet below ground surface

µg/kg = Micrograms per kilogram

mg/kg = Milligrams per kilogram

pCi/g = PicoCuries per gram

WTPH-D,G = Washington Total Petroleum Hydrocarbons - diesel, gasoline

ND = Not detected above laboratory method reporting limit

NA = Not available

ARAR = Applicable or relevant and appropriate requirement for constituents detected during the PA/SI that were not detected during the RI.

(1) Project screening goal (PSG) for TPH-G = 100 mg/kg; PSG for TPH-D = 200 mg/kg.

(a) = Model Toxics Control Act Method B Non-Cancer Formula Value.

(b) = Model Toxics Control Act Method B Cancer Formula Value.

(c) = 90th percentile value for the Puget Sound Region (As, Be, Cd, Cr, Cu, Pb, Ni, and Zn) or Washington State (Se and Ag) (Washington State Department of Ecology, 1994b).

* = These values were based on analysis for total petroleum hydrocarbons by USEPA Method 418.1. The WTPH-D,G analyses yielded ND results.

Shaded cells indicate a detection above the associated RI project screening goal or ARAR.

Constituent Abbreviations

Sb = Antimony

Cu = Copper

Tl = Thallium

As = Arsenic

Hg = Mercury

Pb = Lead

Be = Beryllium

Ni = Nickel

Zn = Zinc

Cd = Cadmium

Se = Selenium

Cr = Chromium

Ag = Silver

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TABLE 3-2

Summary of PA/SI Groundwater Chemical Quality Data
143rd CCSQ, Seattle ANG, Seattle, Washington
Source: Optech, 1995

Location	Volatile Organic Compounds (USEPA Method 8240) (µg/l)	Semi-volatile Organic Compounds (USEPA Method 8270) (µg/l)	Total Petroleum Hydrocarbons (WTPH-D) (µg/l)	Polychlorinated Biphenyls (USEPA Method 8060) (µg/l)	Radionuclides (USEPA Method 9310) (pCi/l)		Trace Metals* (µg/l)													
					Gross Alpha	Gross Beta	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Se	Tl	Zn	
Background (BS-004PZ)	ND	ND	ND	ND	84 ± 42	78 ± 25	ND	38	13	0.6	120	290	33	ND	160	ND	ND	5.7	450	
BS-005PZ	ND	ND	ND	ND	15 ± 39	77 ± 24	ND	28	840	ND	5.2	54	22	ND	31	ND	2	ND	ND	
BS-006PZ	ND	ND	ND	ND	59 ± 59	58 ± 30	ND	27	820	ND	97	78	26	ND	60	ND	3.1	ND	ND	
RI Project Screening Goal					15	11.3		5				1,000			100				5,000	
ARAR									4 (a)	5 (a,b)	50 (b)		5 (b)				50 (a)	2 (a)		

PA/SI = Preliminary Assessment/Site Inspection

RI = Remedial Investigation

* = Total concentrations in unfiltered samples

USEPA = United States Environmental Protection Agency

µg/l = Micrograms per liter

pCi/l = PicoCuries per liter

WTPH-D = Washington Total Petroleum Hydrocarbons - diesel

ND = Not detected above laboratory method reporting limit

ARAR = Applicable or relevant and appropriate requirement for constituents detected during the PA/SI that were not detected during the RI.

(a) = Federal Primary Maximum Contaminant Level (MCL)

(b) = Model Toxics Control Act Method A Table Value

Shaded cells indicate a detection above the associated RI project screening goal or ARAR.

Constituent Abbreviations

Sb = Antimony	Hg = Mercury
As = Arsenic	Ni = Nickel
Be = Beryllium	Se = Selenium
Cd = Cadmium	Ag = Silver
Cr = Chromium	Tl = Thallium
Cu = Copper	Zn = Zinc
Pb = Lead	

Constituents detected in groundwater at concentrations above MTCA Method A Cleanup Levels, Federal MCLs, and/or site-specific background concentrations include gross alpha radiation, gross beta radiation, arsenic, beryllium, chromium, lead, nickel, and thallium. The PA/SI groundwater samples submitted for metals analysis were unfiltered.

3.4.2.5 Conclusions and Recommendations of the PA/SI Report

The PA/SI report recommended further investigation at the IRP site to determine the source and areal extent of TPH detected in soil and gross alpha and gross beta radiation detected in soil and groundwater. The PA/SI report also noted that State or Federal regulatory standards were exceeded for several trace metals in soil and/or groundwater, but concentrations of those metals did not exceed site-specific background concentrations, with the exception of beryllium in groundwater.

3.4.3 Phase I Remedial Investigation

This section summarizes the results of the Phase I RI conducted at the Seattle ANGS (ERM, 1998), including information regarding background soil and groundwater quality and site characterization results for the IRP site.

3.4.3.1 Scope of Work

Field work for the Phase I RI was performed between September 1996 and July 1997. The Phase I RI included a focused investigation of the IRP site, as well as a general sitewide investigation. The field work consisted of a Geoprobe/HydroPunch groundwater investigation; collection of surface soil and storm sewer catch basin samples; collection of subsurface soil samples from soil borings; installation and quarterly sampling of groundwater monitoring wells; and aquifer slug testing.

3.4.3.2 Geoprobe/HydroPunch Groundwater Investigation Results

Constituents detected in Geoprobe/HydroPunch groundwater samples are summarized on Table 3-3 and presented on Figure 3-5. Benzene and trichloroethylene (TCE) were each detected in two separate groundwater samples collected in the southern portion of the Station, at concentrations that exceed the MTCA Method A Cleanup Level for these compounds (5 micrograms per liter [$\mu\text{g}/\text{l}$]). No other constituents were detected in the

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TABLE 3-3

*Constituents Detected in Phase I RI Geoprobe/HydroPunch Groundwater Samples
143rd CCSQ, Seattle ANG, Seattle, Washington*

Location	Date	Benzene	Toluene	Ethylbenzene	Total Xylenes	Cis-1,2-Dichloroethene	1,2-Dichloroethane	1,1,1-Trichloroethane	Trichloroethene
GP-2	10/8/96	ND	ND	ND	ND	2	ND	ND	3.7
GP-3	10/8/96	7.6	ND	ND	ND	ND	2.4	ND	ND
GP-4	10/8/96	ND	ND	ND	ND	2	ND	ND	17
GP-5	10/8/96	2.7	1.6	9.9	ND	3.9	ND	ND	4.1
GP-15	10/9/96	ND	ND	ND	ND	5	ND	ND	ND
GP-22	10/9/96	ND	ND	ND	7	ND	ND	2	ND
Project Screening Goal		5	40	30	20	70	5	200	5

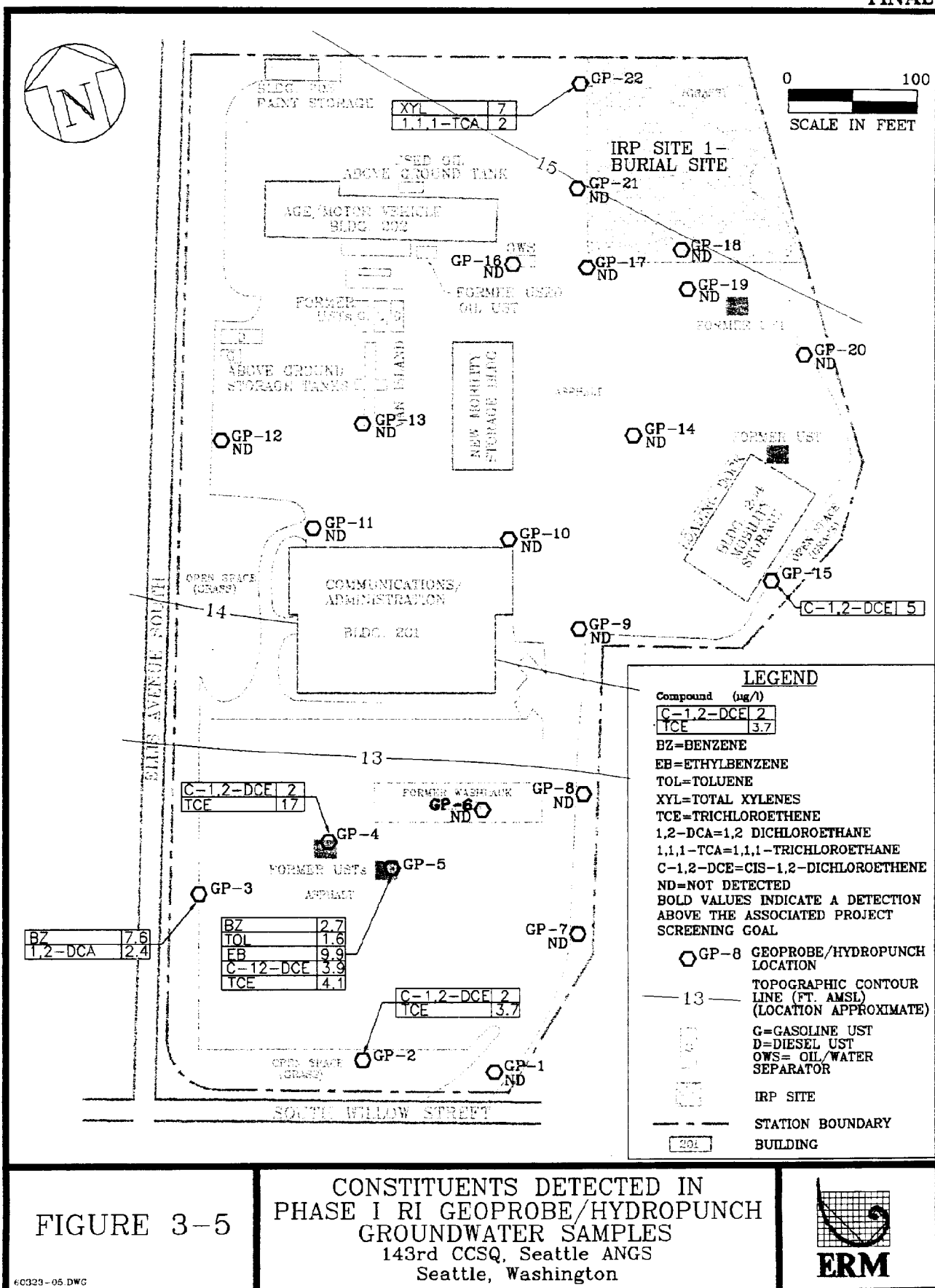
3-14

All concentrations in micrograms per liter (µg/l).

ND = Not detected above laboratory method reporting limit

Shaded cells indicate a detection above the associated project screening goal

Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.



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Geoprobe/HydroPunch groundwater samples at concentrations above PSGs.

3.4.3.3 *Surface Soil Sampling Results*

Constituents detected in surface soil samples are summarized on Table 3-4 and presented on Figure 3-6. Gross alpha radiation concentrations detected in three samples exceeded the site-specific mean background concentration of 9.96 picoCuries per gram (pCi/g).

The gross beta radiation concentration detected in one sample exceeded the site-specific mean background concentration of 16.1 pCi/g. No regulatory standards (maximum acceptable concentrations) have been established for gross alpha or gross beta radiation in soil.

3.4.3.4 *Storm Sewer Catch Basin Sampling Results*

Constituents detected in storm sewer catch basin samples are summarized on Table 3-5 and presented on Figure 3-7. The catch basin samples consisted of a mixture of sediment and water, and were analyzed as a liquid matrix due to the consistency of the samples. Acetone, p-isopropyltoluene, toluene, radionuclides, and trace metals were detected in the catch basin samples.

The Seattle ANGS does not have or require a stormwater permit, and there are no specific regulatory criteria governing the quality of water or sediment present in the Station's storm sewer system. Consequently, no PSGs were developed for constituents detected in catch basin samples. However, based on the catch basin sample analytical results, the storm sewer system does not appear to be a significant pathway for off-site migration of contaminants. Additionally, no potential sources of the constituents detected in the catch basin samples have been identified at the Station.

3.4.3.5 *Subsurface Soil Sampling Results*

Constituents detected in subsurface soil samples are summarized on Tables 3-6 and 3-7. Maximum concentrations of constituents detected in subsurface soil samples are presented on Figures 3-8 and 3-9. The detected concentrations of gross alpha, gross beta, radium-226, and radium-228 in selected subsurface soil samples exceed the site-specific mean background concentrations of these constituents. No other constituents were detected in subsurface soil samples at concentrations above PSGs.

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TABLE 3-4
Constituents Detected in Phase I RI Surface Soil Samples
143rd CCSQ, Seattle ANG, Seattle, Washington

Location	Date	Depth (ft-bgs)	Total Petroleum Hydrocarbons (mg/kg)			Radionuclides (pCi/g)							
			Gasoline	Diesel	Heavy Oil	Gross Alpha (+/-)	Gross Beta (+/-)	Radium-226 (+/-)	Radium-228 (+/-)				
SS-01	10/17/96	0.5	ND	ND	ND	7.4	4.8	16.6	4.3	0.48	0.20	0.82	0.48
SS-02	10/17/96	0.5	ND	ND	ND	6.1	4.6	13.2	4.0	0.57	0.23	0.57	0.42
SS-03	10/17/96	0.5	23	63	ND	10.5	5.3	14.7	4.2	0.44	0.20	0.23	0.39
SS-04	10/17/96	0.5	ND	ND	ND	10.3	5.5	13	4.1	0.54	0.19	0.59	0.41
SS-05	10/17/96	0.5	ND	ND	ND	7.3	5.0	14.6	4.2	0.53	0.22	0.64	0.41
SS-06	10/17/96	0.5	ND	ND	ND	4	4.2	9	3.9	0.23	0.17	0.48	0.48
SS-06 (dup)	10/17/96	0.5	ND	ND	ND	3.4	4.2	8.5	3.8	0.29	0.17	0.7	0.43
SS-07	10/17/96	0.5	ND	70	ND	3	4.7	13.1	4.1	0.44	0.20	0.54	0.44
SS-08	10/17/96	0.5	ND	ND	102	7.5	4.9	8.9	3.7	0.39	0.19	0.83	0.45
SS-09	10/17/96	0.5	ND	66	110	11.9	5.9	12.9	3.9	0.65	0.17	0.71	0.78
SS-10	10/17/96	0.5	35	ND	ND	6.5	4.6	14.3	4.0	0.65	0.23	0.42	0.57
Project Screening Goal			100	200	200	9.96		16.1		0.77		0.93	

ft-bgs = Feet below ground surface

dup = Duplicate sample

mg/kg = Milligrams per kilogram

pCi/g = PicoCuries per gram

+/- = Margin of error (pCi/g)

ND = Not detected above laboratory method reporting limit

Shaded cells indicate a detection above the associated project screening goal

3-17

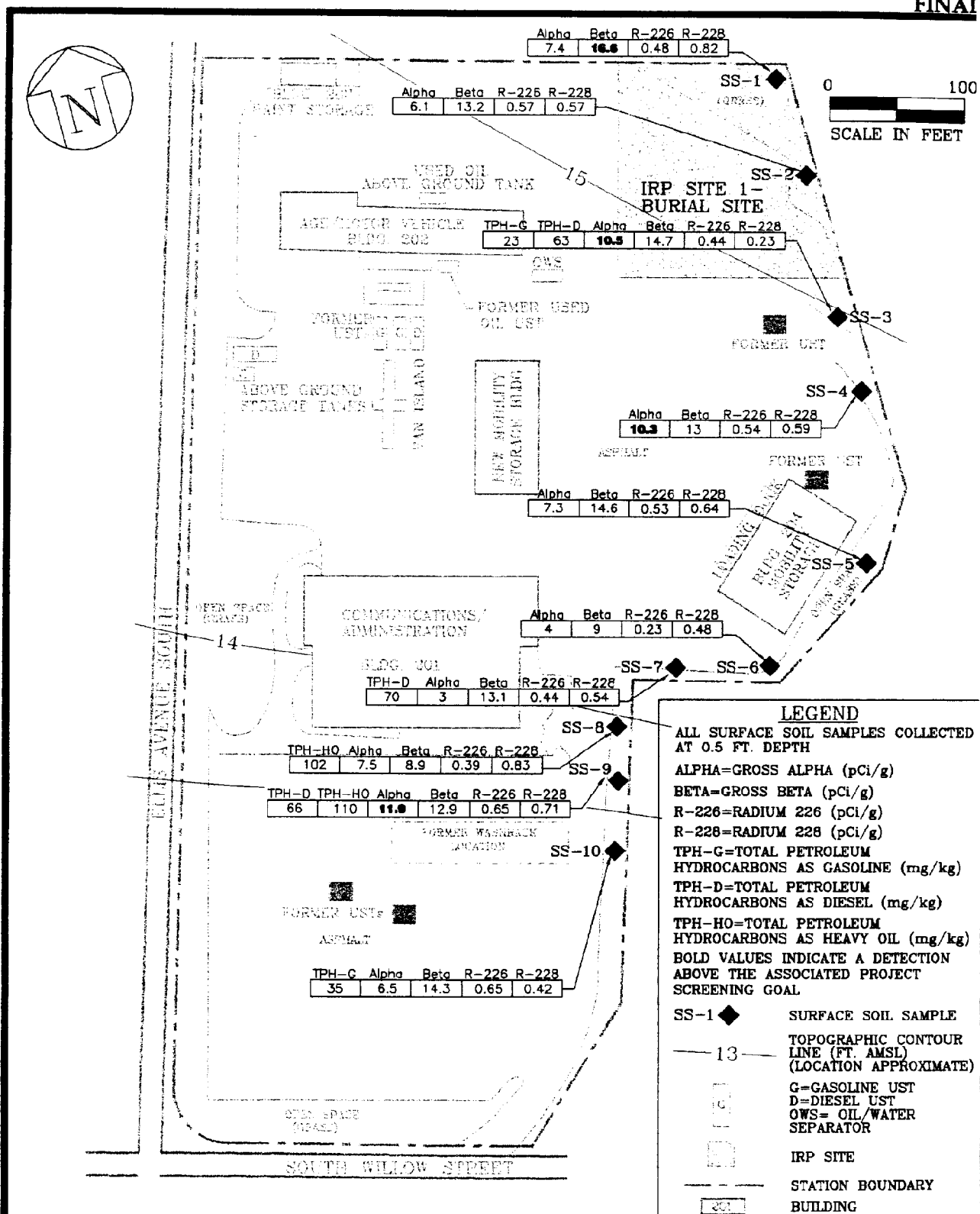


FIGURE 3-6

CONSTITUENTS DETECTED IN PHASE I RI SURFACE SOIL SAMPLES

143rd CCSQ, Seattle ANG
Seattle, Washington



FINAL

TABLE 3-5
Constituents Detected in Phase I RI Storm Sewer Catch Basin Samples
143rd CCSQ, Seattle ANG, Seattle, Washington

Location	Date	VOCs (µg/l)			Radionuclides (pCi/l)								Trace Metals (µg/l)						
		Acetone	p-IPT	Toluene	Gross Alpha (+/-)	Gross Beta (+/-)	Radium-226 (+/-)	Radium-228 (+/-)	Antimony	Arsenic	Cadmium	Chromium	Copper	Nickel	Zinc				
SW-1	7/11/97	18	2.5	19	18	4.6	17.4	2.9	0.12	0.16	1.01	0.48	310	14	44	87	410	62	1,100
SW-2	7/11/97	ND	ND	ND	29.1	7.6	23.9	4.6	0.06	0.14	0.52	0.60	350	ND	21	29	160	20	340

VOCs = Volatile organic compounds

p-IPT = p-isopropyltoluene

µg/l = Micrograms per liter

pCi/l = PicoCuries per liter

ND = Not detected above laboratory method reporting limit

+/- = Margin of error (pCi/l)

3-19

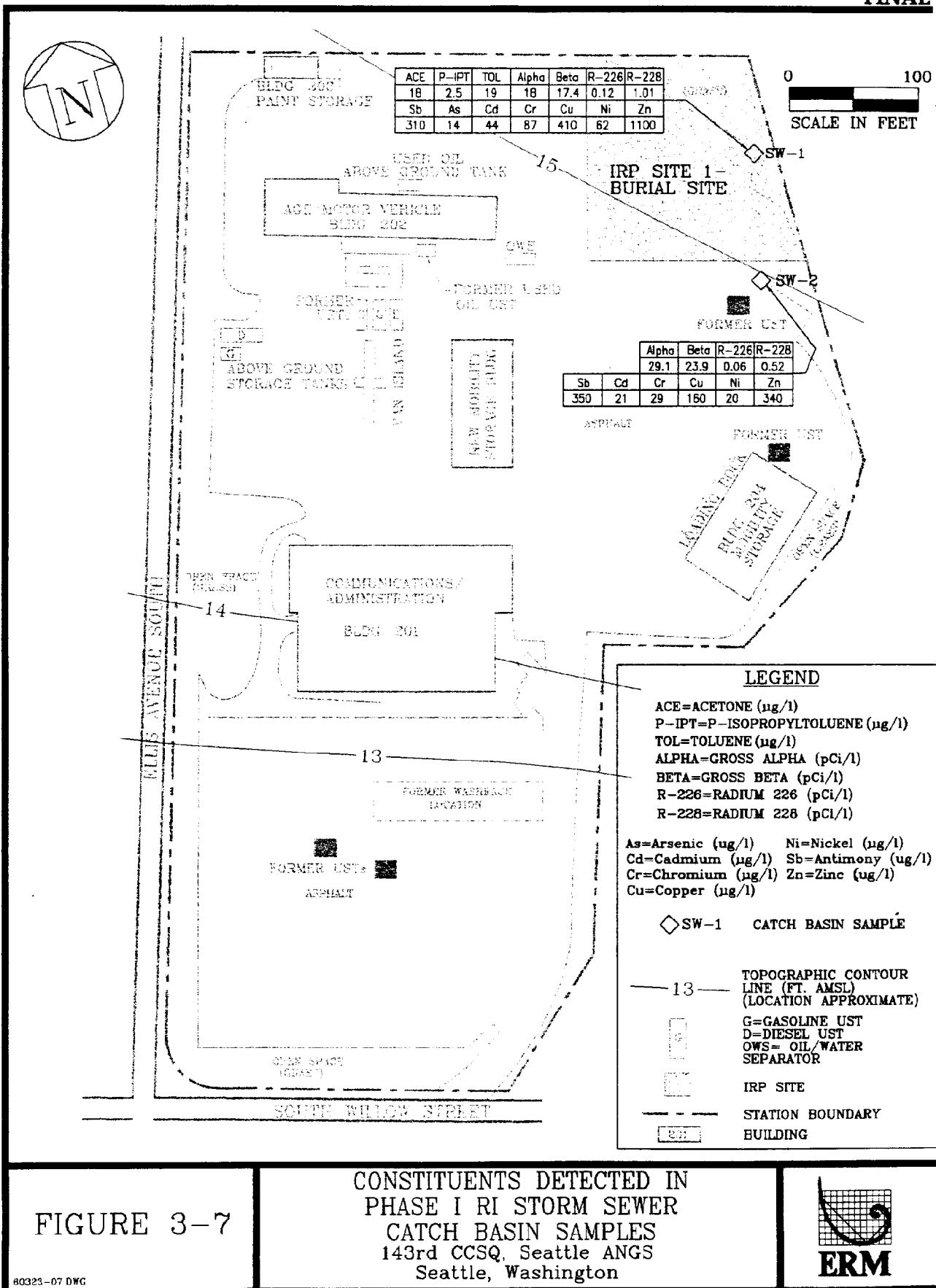


TABLE 3-6
Constituents Detected in Phase I RI Background Subsurface Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Sample Depth (ft-bgs)	Radionuclides (pCi/g)						Trace Metals (mg/kg)								
			Gross Alpha (cpd)	Gross Beta (cpd)	Radium-226 (cpd)	Radium-228 (cpd)	Radium-234 (cpd)	Arsenic (ppm)	Chromium	Copper	Lead	Nickel	Selenium	Zinc			
SB-1	10/15/96	3.0	11	5.5	16	4.3	0.29	0.17	0.46	0.68	14	19	15	10	ND	27	
		7.0	8	5.0	15.1	4.1	0.69	0.21	1.34	0.68	2.2	8	6	ND	7	0.6	15
		9.0	7.6	5.3	16.6	4.2	0.74	0.22	0.69	0.43	1.8	10	7	ND	6	ND	16
SB-2	10/15/96	5.0	6.3	4.9	12.7	4.0	0.71	0.22	0.70	0.38	7	14	20	33	12	2.2	45
		7.0	7.5	4.9	14.5	4.2	0.88	0.24	0.77	0.43	2.6	13	17	14	9	1.5	26
		9.0	9.2	5.1	16.1	4.5	0.31	0.16	0.82	0.18	2.5	15	10	11	7	1.4	21
SB-3	10/15/96	3.0	12.8	5.9	15.7	4.2	0.76	0.24	0.87	0.42	8.7	17	15	20	14	2.8	30
		7.0	8.1	5.3	16.0	4.1	0.66	0.23	0.38	0.40	0.8	10	8	6	6	ND	14
		9.0	6.8	5.0	15.3	4.1	0.71	0.23	0.76	0.48	2.7	8	7	ND	7	ND	19
95% UCL Mean Concentration			9.96		16.1		0.77		0.93		5.59	14.2	15.8	18.2	10.5	1.66	30.1
Project Screening Goal			9.96		16.1		0.77		0.93		20	100	2,960	250	1,600	400	24,000

RI = Remedial Investigation

mg/kg = Milligrams per kilogram

pCi/g = PicoCuries per gram

ND = Not detected above laboratory method reporting limit

ft-bgs = Feet below ground surface

+/- = Margin of error (pCi/g)

UCL = Upper confidence limit

Shaded cells indicate a detection above the associated project screening goal.

Note: The 95% UCL mean concentration calculation included all RI background samples. For samples that were "ND" for a given constituent,

a value equal to one-half of the associated method reporting limit was used in the 95% UCL mean concentration calculation (per

WAC 173-340-7100).

TABLE 3-7

Constituents Detected in Phase I RI Site-Characterization Subsurface Soil Samples
143rd CCSQ, Seattle ANG, Seattle, Washington

Location	Date	Depth (ft-bgs)	VOCs (µg/kg)	SVOCs (µg/kg)	Radionuclides (pCi/g)								Trace Metals (mg/kg)							
			TCE	B(2-EH)P	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium- 226	(+/-)	Radium- 228	(+/-)	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Selenium	Zinc
SB-04	10/15/96	3	NA	ND	15	6.1	14.7	4.0	0.7	0.24	0.61	0.39	11	0.8	16	35	110	16	1.5	100
SB-04	10/15/96	9	NA	ND	6.7	4.7	16.6	4.2	0.62	0.22	0.13	0.58	4.8	ND	17	23	19	10	1.4	39
SB-05	10/15/96	3	NA	ND	16.2	6.4	15.6	4.2	0.92	0.25	0.35	0.57	8.2	ND	14	26	45	12	1.4	47
SB-05	10/15/96	9	NA	ND	12.4	6.0	16.9	4.2	0.33	0.17	0.62	0.52	5.4	ND	19	25	18	24	1.5	40
SB-06	10/15/96	3	NA	ND	12.5	5.8	13.4	4.1	0.61	0.22	1.21	0.73	3.1	ND	16	16	10	4	0.8	10
SB-06 (dup)	10/15/96	3	NA	ND	13.1	6.0	15.5	4.2	0.48	0.20	0.76	0.57	NA	NA	NA	NA	NA	NA	NA	NA
SB-06	10/15/96	9	NA	ND	6.7	5.4	18	4.4	0.45	0.19	0.44	0.62	ND	ND	9	5	8	4	ND	14
SB-06 (dup)	10/15/96	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.7	ND	15	9	11	7	ND	19
SB-07	10/15/96	3	NA	ND	16.1	6.4	17.1	4.3	1.37	0.32	0.85	0.64	13	ND	12	10	19	7	ND	16
SB-07	10/15/96	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	13	6	8	4	ND	15
SB-08	10/16/96	3	NA	ND	5	4.4	11.7	3.9	0.55	0.20	0.57	0.47	11	ND	14	31	64	13	ND	89
SB-08	10/16/96	9	NA	ND	8.7	5.9	14.2	4.2	0.66	0.21	0.68	0.44	4.5	ND	16	26	17	12	ND	38
SB-09	10/16/96	3	NA	ND	8.2	5.2	14	4.2	0.86	0.24	0.53	0.42	12	ND	13	21	76	10	ND	42
SB-09 (dup)	10/16/96	3	NA	ND	10.5	5.5	15.7	4.2	0.63	0.23	0.56	0.47	20	ND	16	28	250	14	ND	210
SB-09	10/16/96	9	NA	3,900	8.4	5.1	22.9	4.7	0.64	0.21	0.93	0.47	5.3	ND	16	18	13	16	ND	49
SB-10	10/16/96	3	NA	ND	6.4	4.9	14.2	4.1	0.76	0.26	1.01	0.45	4.3	ND	10	11	11	7	ND	19
SB-10	10/16/96	9	NA	ND	5.8	4.5	13.4	3.9	0.85	0.26	1.29	0.52	4.6	ND	11	15	18	7	ND	22
SB-11	10/16/96	3	NA	ND	4.9	4.5	14.7	4.1	0.58	0.21	0.54	0.48	4	ND	11	18	15	7	ND	28
SB-11	10/16/96	9	NA	ND	8.7	5.8	15.7	4.3	0.47	0.21	1.23	0.51	6.9	ND	18	22	20	20	ND	43
MW-3	10/17/96	5	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-3	10/17/96	9	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Project Screening Goal			500	71,400	9.96		16.1		0.77		0.93		20	2	100	2,960	250	1,600	400	24,000

VOCs = Volatile organic compounds

SVOCs = Semivolatile organic compounds

TCE = Trichloroethene

B(2-EH)P = Bis(2-ethylhexyl)phthalate

mg/kg = Milligrams per kilogram

pCi/g = PicoCuries per gram

µg/kg = Micrograms per kilogram

Shaded cells indicate a detection above the associated project screening goal

ft-bgs = Feet below ground surface

ND = Not detected above laboratory method reporting limit

NA = Not analyzed

+/- = Margin of error (pCi/g)

dup = Duplicate sample

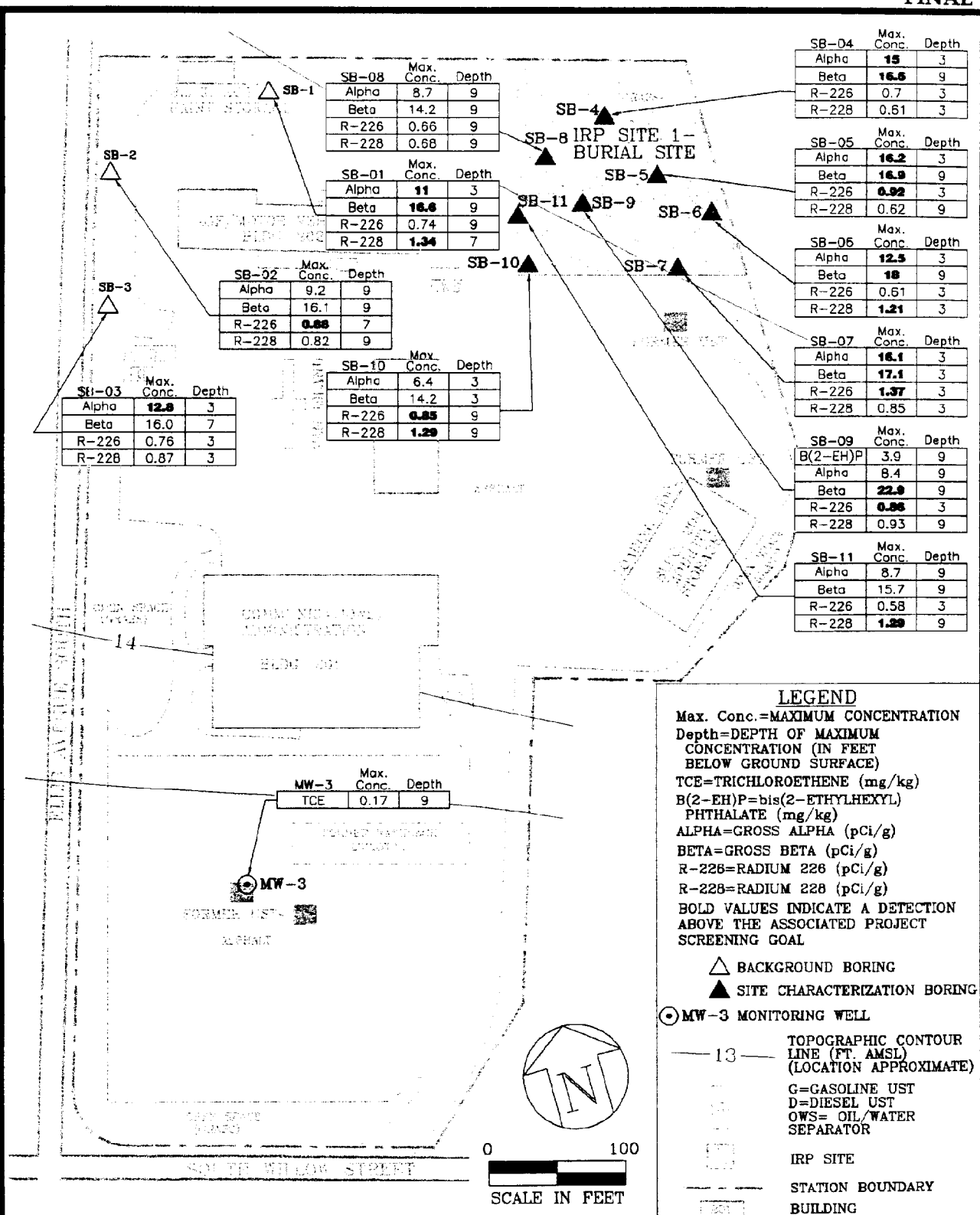


FIGURE 3-8

MAXIMUM CONCENTRATIONS OF ORGANIC COMPOUNDS AND RADIONUCLIDES DETECTED IN PHASE I RI SUBSURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANG
Seattle, Washington



60323-06 DWG

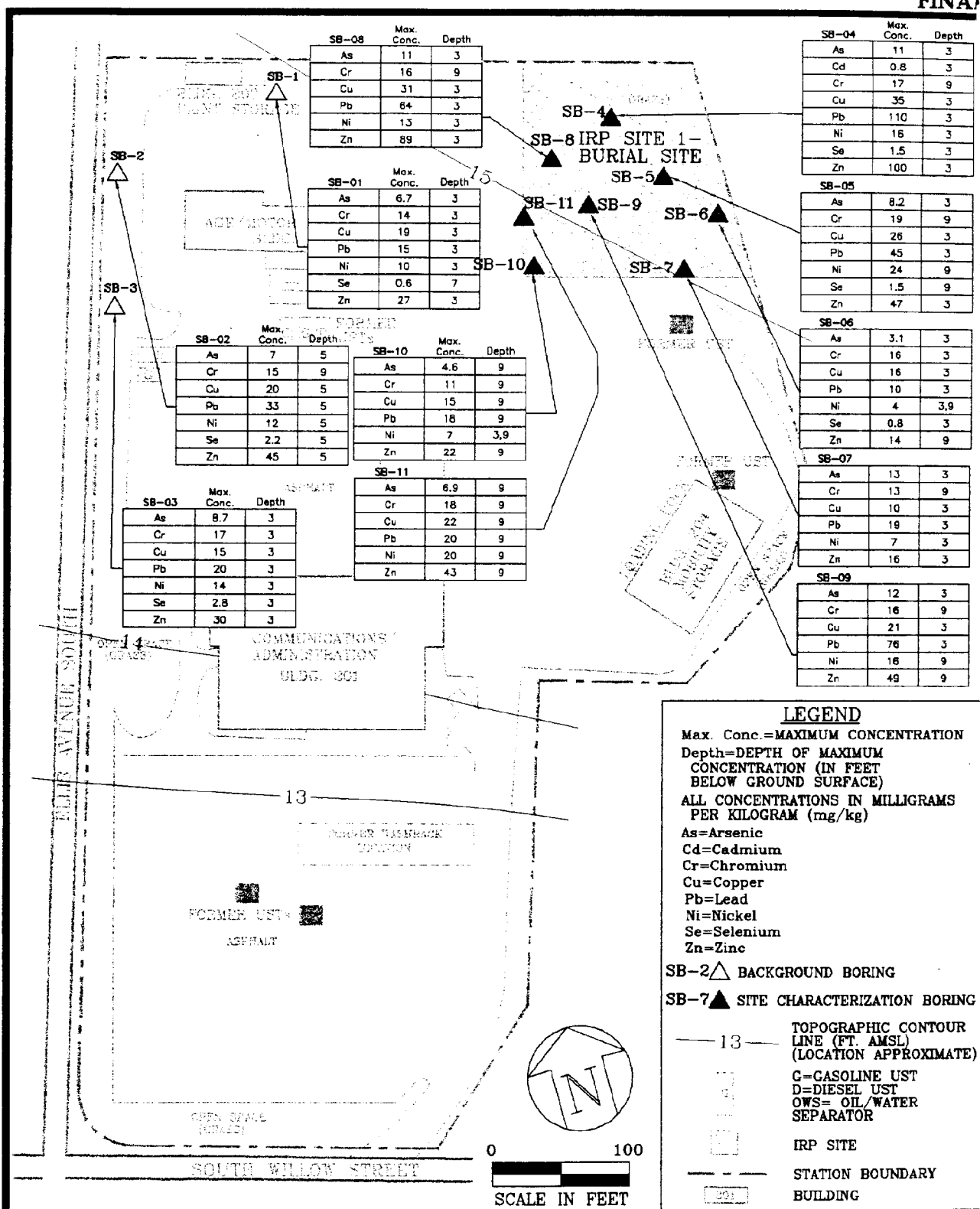


FIGURE 3-9

MAXIMUM CONCENTRATIONS OF
METALS DETECTED IN PHASE I RI
SUBSURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANG
Seattle, Washington



3.4.3.6 Quarterly Groundwater Sampling Results

Constituents detected in groundwater samples collected from monitoring wells are summarized on Tables 3-8 through 3-11. Maximum concentrations of constituents detected in these groundwater samples are presented on Figures 3-10 and 3-11.

Two groundwater samples collected from a background well (well BS-004PZ) contained concentrations of tetrachloroethylene (PCE) that exceed the MTCA Method A Cleanup Level of 5 µg/l. Selected samples collected from all the monitoring wells contained concentrations of gross beta radiation that exceed the site-specific mean background concentration. Dissolved arsenic was detected in one groundwater sample at a concentration that exceeds the MTCA Method A Cleanup Level of 5 µg/l.

3.4.3.7 Conclusions and Recommendations of the Phase I RI Report

Constituents detected above PSGs in soil at the Seattle ANGS during the Phase I RI include gross alpha, gross beta, radium-226, and radium-228 radionuclides. Constituents detected above PSGs in groundwater include benzene, TCE, PCE, gross beta, and dissolved arsenic. The Phase I RI report concluded that the radionuclides detected in soil and groundwater reflect naturally-occurring background concentrations. The single reported detection of arsenic in one groundwater sample was considered an anomaly, because arsenic was not detected in any of four prior or subsequent groundwater samples collected from the subject monitoring well, and there are no known sources of arsenic at the Station.

The Phase I RI report recommended further investigation of the southern and northwest portions of the Station to determine the source and extent of dissolved VOCs in groundwater. The Phase I RI report also recommended using the data collected during the additional investigations to refine the preliminary estimates of human health risks obtained from the Phase I baseline risk assessment.

TABLE 3-8

*Constituents Detected in Phase I RI Background Groundwater Samples
143rd CCSQ, Seattle ANG, Seattle, Washington*

Location	Date	Volatile Organic Compounds (µg/l)				Radionuclides (pCi/l)								Trace Metals* (µg/l)		
		1,1-DCA	PCE	1,1,1-TCA	Toluene	Gross Alpha (+/-)	Gross Beta (+/-)	Radium-226 (+/-)	Radium-228 (+/-)	Copper	Nickel	Zinc				
BS-004PZ	9/17/96	0.3	3.8	3.7	(ND)	2.2	1.7	13.2	2.1	0.2	0.18	-0.08	0.51	ND	ND	ND
	9/17/96 (dup)	0.3	3.8	3.8	(ND)	0.2	1.1	11.7	2	0.19	0.15	-0.6	0.45	ND	ND	ND
	1/14/97	ND	5.1	2.4	ND	2.1	1.5	9.9	1.8	0.02	0.12	0.25	0.4	ND	ND	61
	4/11/97	ND	17	3.3	ND	1.3	1.3	6.8	1.7	0.04	0.12	0.29	0.38	5	ND	(ND)
	7/10/97	ND	(ND)	1.8	ND	0.9	1.2	8.6	1.8	0.05	0.13	0.22	0.41	6	ND	(ND)
MW-1	10/18/96	ND	ND	ND	ND	0.5	1	8.1	1.8	0.27	0.18	0.08	0.44	ND	ND	ND
	12/17/96	ND	ND	ND	ND	3.9	1.9	12.7	2.1	0.18	0.18	0.2	0.37	ND	8	(ND)
	1/14/97	ND	ND	ND	1.1	-0.09	0.84	10.4	1.9	0.35	0.24	0.31	0.44	ND	8	61
	4/11/97	ND	ND	ND	ND	0	1.1	1.03	1.9	0.22	0.15	0.02	0.37	ND	13	(ND)
	7/11/97	ND	ND	ND	ND	-0.3	1	9	1.8	0.19	0.16	0.2	0.6	19	7	(ND)
95% UCL Mean Concentration		0.513	7.33	2.63	1.04	2.09		11.3		0.236		0.258		8.06	9.66	51
Project Screening Goal		800	5	200	40	15		11.3		3		2		1,000	100	5,000

RI = Remedial Investigation

* = Dissolved concentrations in filtered samples

ND = Not detected above laboratory method reporting limit

(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory

Program "10x" and "5x" rules).

pCi/l = PicoCuries per liter

µg/l = Micrograms per liter

+/- = Margin of error (pCi/l)

dup = Duplicate sample

UCL = Upper confidence limit

Shaded cells indicate a detection above the associated project screening goal.

Note: The 95% UCL mean concentration calculation included all RI background samples. For samples that were "ND" for a given constituent, a value equal to one-half of the associated method reporting limit was used in the calculation (per WAC 173-340-708).

Constituent Abbreviations

1,1-DCA = 1,1-Dichloroethane

PCE = Tetrachloroethene

1,1,1-TCA = 1,1,1-Trichloroethane

FINAL

TABLE 3-9

*Organic Constituents Detected in Phase I RI Site-Characterization Groundwater Samples
143rd CCSQ, Seattle ANG, Seattle, Washington*

Location	Date	Acetone	Cis-1,2- Dichloroethene	1,3,5- Trimethylbenzene	Tetrachloroethene	Trichloroethene
BS-005PZ	9/17/96	ND	ND	0.2	ND	ND
BS-005PZ	7/11/97	ND	ND	ND	4.7	ND
BS-006PZ	9/17/96	ND	ND	0.2	ND	ND
MW-03	10/18/96	18	ND	ND	ND	ND
MW-03	10/18/96 (dup)	20	ND	ND	ND	ND
MW-04	10/18/96	11	ND	ND	ND	3.9
MW-04	12/17/96	ND	ND	ND	ND	2.7
MW-04	1/14/97	ND	ND	ND	ND	3.4
MW-04	4/11/97	ND	ND	ND	ND	3.2
MW-04	7/11/97	ND	ND	ND	ND	2.8
MW-05	10/18/96	ND	5.6	ND	ND	ND
MW-05	12/17/96	ND	4.9	ND	ND	ND
MW-05	1/14/97	ND	2.7	ND	ND	ND
MW-05	4/11/97	ND	1.4	ND	ND	ND
MW-05	4/11/97 (dup)	ND	1.6	ND	ND	ND
MW-05	7/10/97	ND	3.5	ND	(ND)	2.1
MW-05	7/10/97 (dup)	ND	2.8	ND	ND	ND
Project Screening Goal		800	70	0.507	5	5

All concentrations in micrograms per liter (µg/l)

ND = Not detected above laboratory method reporting limit.

(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).

dup = Duplicate sample

Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.

TABLE 3-10

**Radionuclides Detected in Phase I RI Site-Characterization Groundwater Samples
143rd CCSQ, Seattle ANG, Seattle, Washington**

Location	Date	Gross Alpha (+/-)		Gross Beta (+/-)		Radium-226 (+/-)		Radium-228 (+/-)	
BS-005PZ	9/17/96	0	1.7	20	3.0	0.07	0.15	0.23	0.49
	1/15/97	2.7	2.2	19.3	2.7	0.11	0.16	0.01	0.42
	4/10/97	-0.14	1.0	14.2	2.2	0.11	0.12	0.43	0.44
	7/10/97	0.6	1.6	13.8	2.4	0.15	0.20	NA	NA
BS-006PZ	9/17/96	0.1	1.6	10.3	2.5	0.04	0.13	0.29	0.45
	1/14/97	-0.1	1.3	11.5	2.0	0.14	0.18	0.14	0.36
	4/10/97	0.1	1.7	10.5	2.1	0.131	0.97	0.07	0.45
	7/10/97	0.4	1.5	10.3	2.3	0.14	0.14	0.19	0.44
MW-02	10/18/96	0.4	1.3	8.8	2.1	0.04	0.15	-0.2	0.43
	12/17/96	3.7	2.0	12.8	2.1	0.11	0.16	0.1	0.41
	1/15/97	0.5	1.3	11.5	2.0	0.04	0.11	0.07	0.35
	1/15/97 (dup)	0.4	1.2	11.5	2.0	0.08	0.13	0.14	0.42
	4/10/97	0.8	1.3	10.8	1.9	0.04	0.14	0.11	0.42
	7/10/97	-0.1	1.3	11.1	2.5	0.11	0.13	0.6	0.42
MW-03	10/18/96	-0.2	1.4	8.3	1.8	0.09	0.17	1.43	0.47
	10/18/96 (dup)	7.8	2.7	8.9	1.8	0.15	0.15	1.88	0.47
	12/17/96	4	2.8	8.9	2.6	0.12	0.17	0.36	0.42
	12/17/96 (dup)	1.8	1.9	9	2.1	0.023	0.10	-0.15	0.40
	1/15/97	-0.2	1.0	8.2	1.8	0.21	0.17	0.12	0.51
	4/10/97	1.4	1.6	14.8	2.2	0.13	0.13	0.26	0.44
	7/10/97	0.3	1.7	17.3	2.9	0.16	0.15	0.78	0.61
MW-04	10/18/96	10.8	3.9	17.2	3.0	0.2	0.17	0.65	0.40
	12/17/96	4.8	2.8	19.1	3.1	0.05	0.13	0.09	0.44
	1/14/97	0.3	1.5	16.4	2.5	0.1	0.19	-0.19	0.44
	4/10/97	0.2	1.2	12.9	2.1	0.11	0.13	0.26	0.37
	7/10/97	-0.67	0.7	11.1	2.1	0.101	0.10	0.15	0.44
MW-05	10/18/96	-0.1	2.1	12.3	2.9	0.5	0.26	1.52	0.44
	12/17/96	5.2	3.4	13.3	3.2	0.13	0.13	0.35	0.37
	1/14/97	1.9	2.8	10.6	3.0	0.21	0.19	0.03	0.43
	4/10/97	1.3	1.7	8.9	2.0	0.16	0.14	-0.4	0.39
	4/10/97 (dup)	0.3	2.1	7.1	2.3	0.16	0.15	0.01	0.35
	7/10/97	-0.4	1.4	9.9	2.4	0.09	0.11	0.53	0.47
Project Screening Goal		15		11.3		3		2	

All concentrations in picoCuries per liter (pCi/l)

dup = Duplicate sample

NA = Not analyzed

+/- = Margin of error (pCi/l)

Shaded cells indicate a detection above the associated project screening goal

TABLE 3-11

*Trace Metals Detected in Phase I RI Site-Characterization Groundwater Samples
143rd CCSQ, Seattle ANG, Seattle, Washington*

Location	Date	Arsenic	Copper	Nickel	Zinc
BS-005PZ	9/17/96	ND	ND	60	10
	1/15/97	ND	ND	15	(ND)
	4/11/97	ND	ND	9	(ND)
	7/11/97	ND	ND	7	(ND)
BS-006PZ	9/17/96	ND	ND	40	ND
	1/14/97	ND	ND	6	(ND)
	4/11/97	ND	ND	10	(ND)
	7/11/97	ND	8	5	(ND)
MW-02	12/17/96	ND	6	15	(ND)
	1/15/97	ND	10	20	(ND)
	1/15/97 (dup)	ND	11	21	50
	4/10/97	ND	20	16	(ND)
	7/11/97	ND	ND	17	(ND)
MW-03	1/15/97	ND	ND	ND	46
	4/11/97	ND	ND	8	(ND)
	7/11/97	ND	13	ND	(ND)
MW-04	12/17/96	ND	ND	7	(ND)
	1/14/97	ND	ND	7	270
	4/11/97	ND	ND	9	(ND)
MW-05	12/17/96	6	ND	9	(ND)
	1/14/97	ND	ND	10	(ND)
	4/11/97	ND	ND	8	(ND)
	4/11/97 (dup)	ND	ND	7	(ND)
	7/10/97	ND	ND	8	(ND)
	7/10/97 (dup)	ND	ND	8	(ND)
Project Screening Goal		5	1,000	100	5,000

All concentrations in micrograms per liter ($\mu\text{g/l}$)

Values shown represent dissolved concentrations in filtered samples.

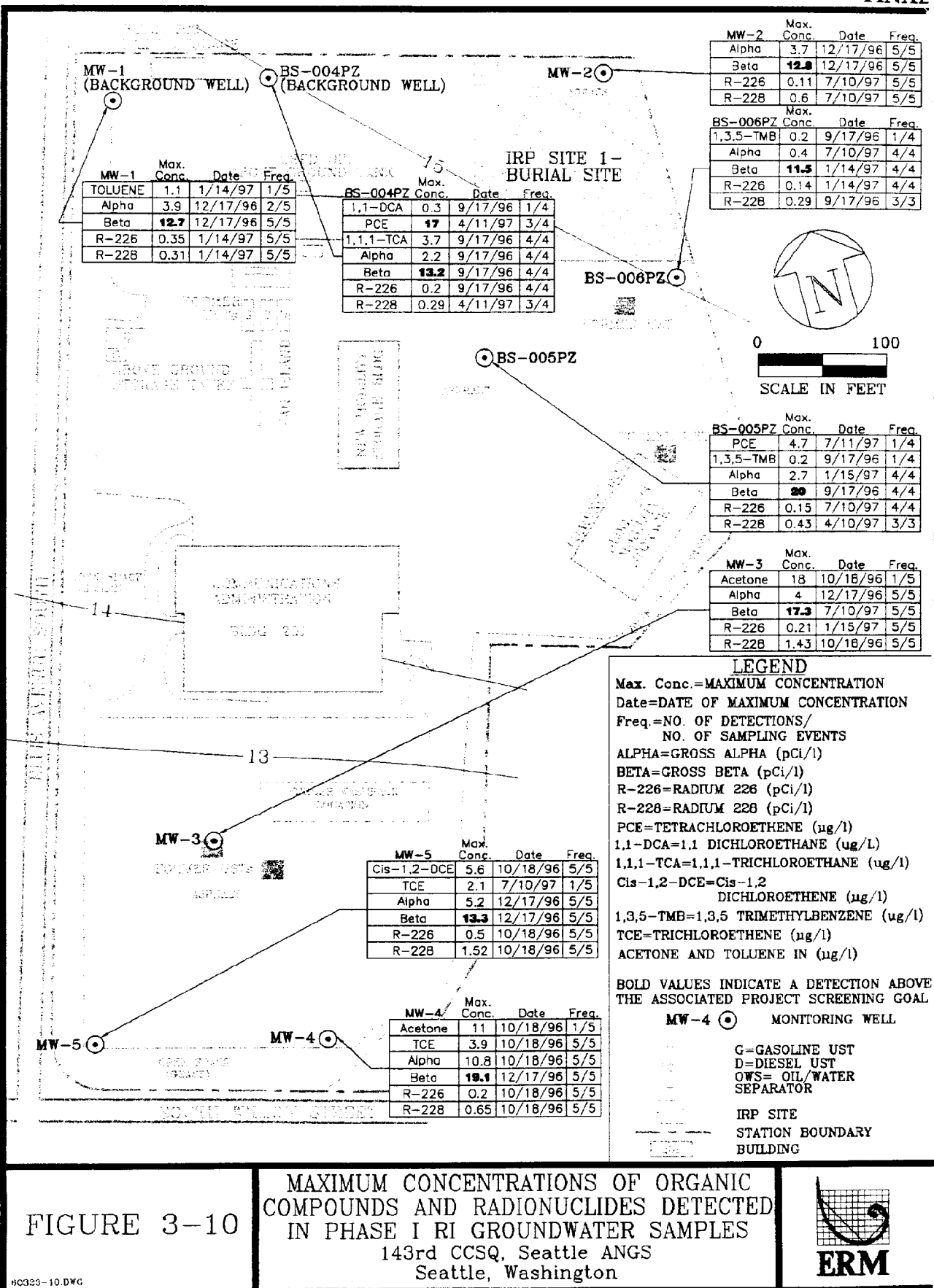
dup = Duplicate sample

ND = Not detected above laboratory method reporting limit

(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).

Shaded cells indicate a detection above the associated project screening goal

Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.



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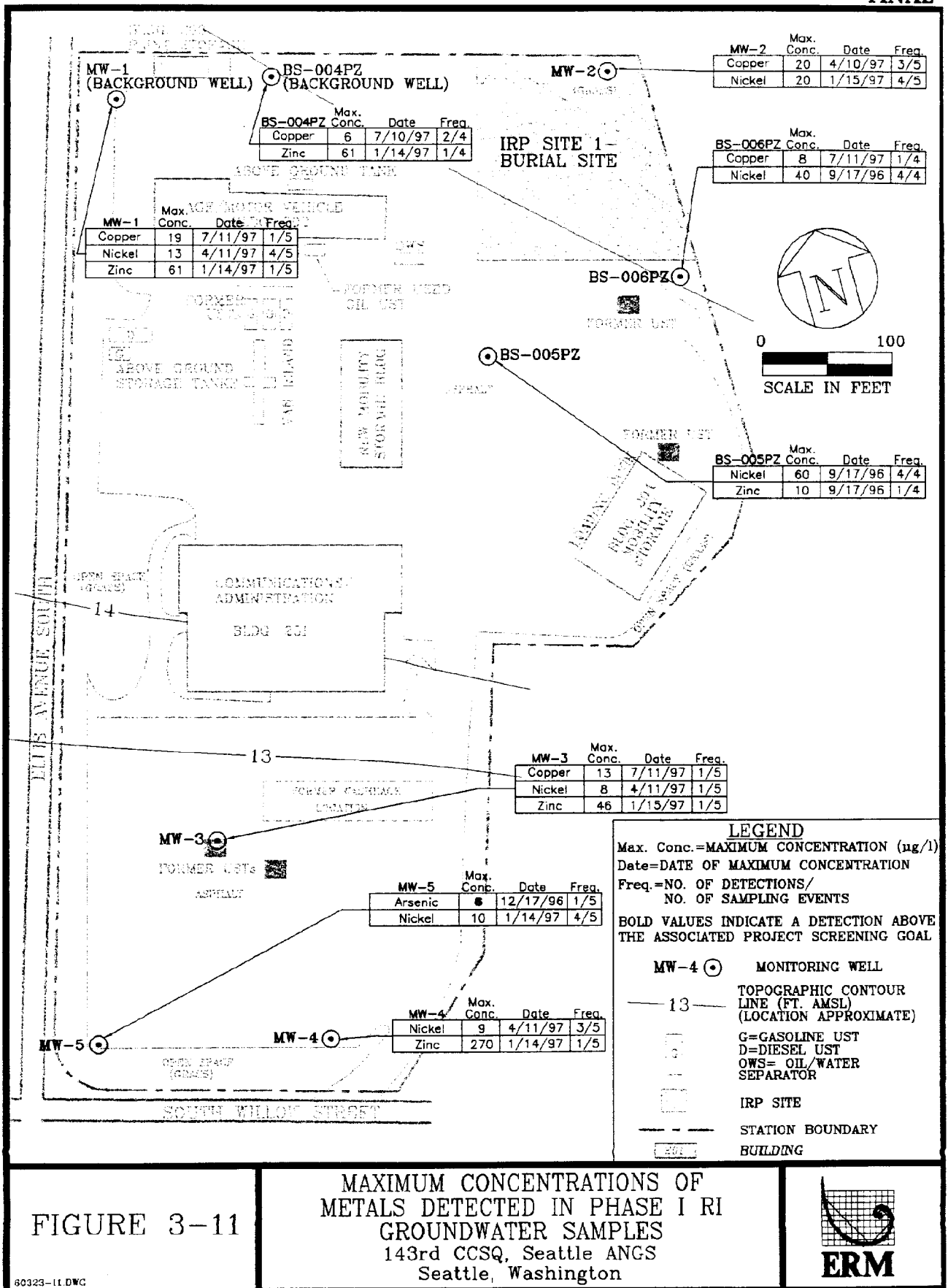


FIGURE 3-11

MAXIMUM CONCENTRATIONS OF
METALS DETECTED IN PHASE I RI
GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANG
Seattle, Washington



60323-11.DWG

SECTION 4.0

ENVIRONMENTAL SETTING

The environmental setting at the Seattle ANGS is presented here to establish a reference for describing the proposed Phase II RI field work.

4.1 Climate

The climate in the Seattle area is characterized by mild summers and cool winters, with long spring and fall seasons. In winter, the daily temperatures range from 37° F to 47° F, while in summer the daily temperatures range from 55° F to 72° F. The average annual precipitation is 38.84 inches, including 7.4 inches of snow. The greatest percentage of rainfall occurs in the winter months from November to January. The average monthly precipitation ranges from 0.89 inches in July to 6.29 inches in December. The heaviest 24-hour rainfall of 3.74 inches was recorded on October 5-6, 1981. Rainfall intensity, based on a 2-year, 24-hour duration, is 2.0 inches. Free water surface evaporation in the Seattle area is approximately 25 inches per year, resulting in a net precipitation of 13.84 inches per year. The prevailing wind is from the southwest, and the highest average wind speed of 9.8 miles per hour occurs during March (OpTech, 1995).

4.2 Topography

The Seattle ANGS is in King County in the Puget Sound Lowlands physiographic province. The Puget Sound Lowlands is a north-south trending structural and topographic depression bordered on the west by the Olympic Mountains and on the east by the Cascade Range. The Lowlands extend north from the Oregon-Washington state line to the Canadian border.

The terrain at the Station is flat and level, with a surface elevation of approximately 7 feet above mean sea level.

4.3 Geology

A geologic map of the Seattle, Washington area and a generalized stratigraphic column for the Puget Sound area are presented on Figures 4-1 and 4-2, respectively.

The Seattle ANGS is situated in the central portion of the Puget Sound Lowlands, a broad glacial drift plain that is dissected by a network of deep marine embayments. The site is located within the north-south trending Duwamish Valley on the Duwamish Waterway flood plain, a former marine embayment that has been filled with sediment since the end of the last glaciation, referred to locally as the Vashon glaciation. The valley is bounded on the east and west by uplands of glacial drift and bedrock.

Glacial sediment deposits known collectively as the Vashon Drift represent the last major advance and retreat of glacial ice in the Puget Sound area, and commonly overlie a sequence of older glacial and nonglacial sediments throughout the site vicinity. Near the site, at least 75 feet of recent alluvium deposited by the Duwamish River overlie the Vashon Drift deposits.

Alluvial deposits in the Duwamish Valley primarily range from silt through silty sand to fine to medium sand. The alluvial deposits exhibit gradation common to meandering rivers, which typically produce intermittent layering of silts and sands with occasional layers of peat and other organic material deposited in marsh areas.

In the 1910s, much of the Duwamish Valley was raised with fill to accommodate development. The meandering Duwamish River was channelized in its present position during this time. Prior to extensive filling and regrading in the vicinity of the Seattle ANGS between 1917 and 1919, a meander of the Duwamish River flowed along the eastern site boundary. Fill materials in the former channel bed in the vicinity of the Station consist of up to 6 feet of silty sand to fine sand and up to 10 feet of coal ash, clinkers, and brick fragments. Soils below the coal combustion residue consist of fine sand with trace gravel to a depth of at least 35 feet bgs (OpTech, 1995).

The subsurface data collected during the PA/SI and Phase I RI drilling activities indicate that the near-surface geology at the Seattle ANGS is predominantly composed of two units. The first unit is a silty sand fill material present to a depth of approximately 8 feet bgs.

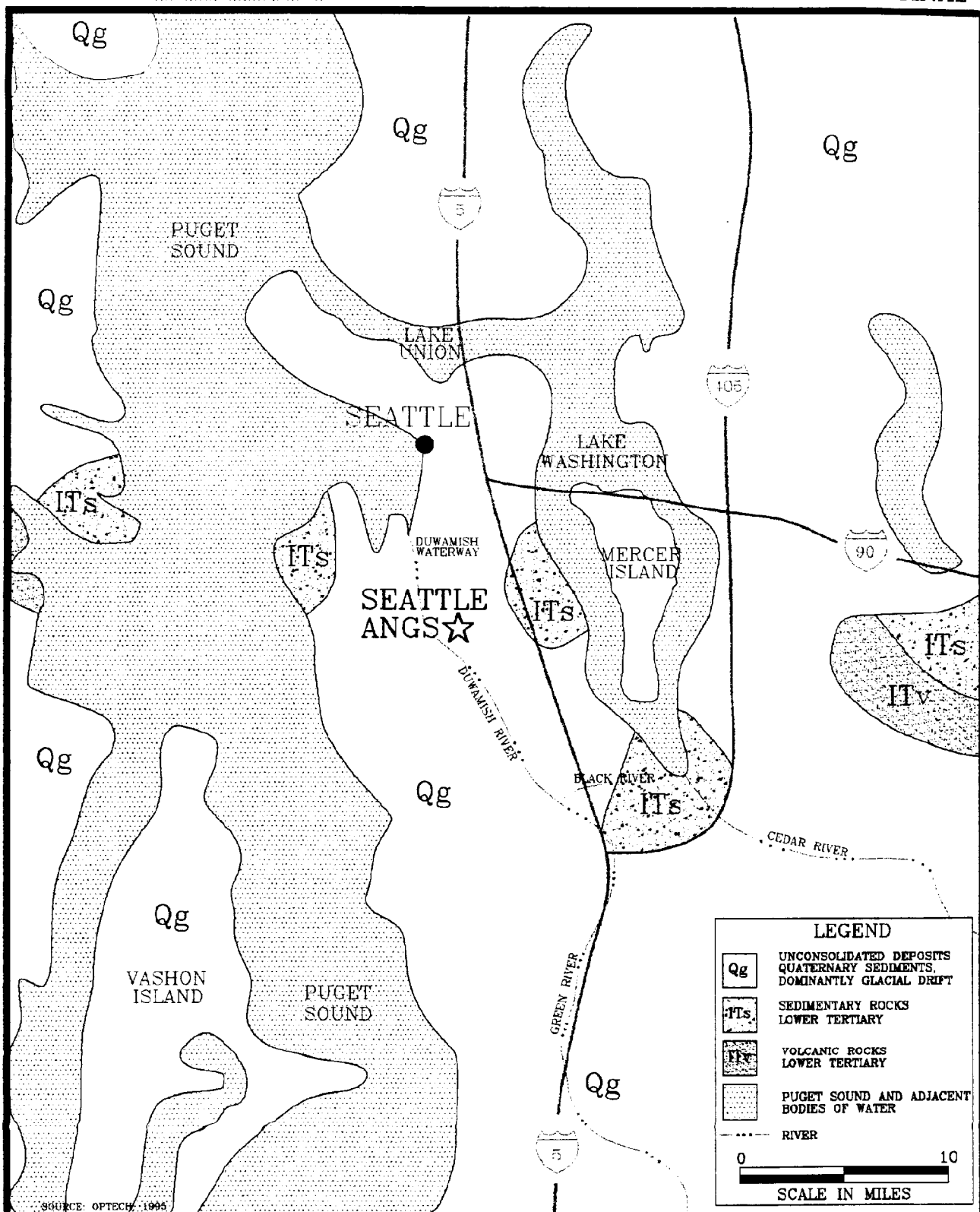


FIGURE 4-1

GEOLOGIC MAP OF THE
SEATTLE, WASHINGTON AREA
143rd CCSQ, Seattle ANGS
Seattle, Washington



60324-01.DWG

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SEA407461

EPOCH	PUGET LOWLAND				AGE (YEARS)			
	SOUTHERN		APPROXIMATE THICKNESS OF SOUTHERN UNITS (FEET)	NORTHERN				
HOLO - CENE	RECENT ALLUVIUM		75					
PLEISTOCENE	LATE	FRASHER DRIFT	VASHON DRIFT	NA	FRASER DRIFT	SUMAS DRIFT	10,000	
						VASHON DRIFT	EVERSON GLACIOMARINE DRIFT	11,000
							VASHON TILL	13,000
							ESPERANCE SAND	
							LAWTON CLAY	
	SEDIMENTS OF THE NONGLACIAL OLYMPIA INTERVAL		NA	SEDIMENTS OF THE NONGLACIAL OLYMPIA INTERVAL		20,000		
	-----		-----	POSSESSION DRIFT		28,000 42,000		
	-----		-----	WHIDBEY FORMATION (INTERGLACIAL)		90,000		
	-----		-----	DOUBLE BLUFF DRIFT		100,000		
	-----		-----	-----		250,000		
	SALMON SPRINGS DRIFT	UPPER SALMON SPRINGS GRAVEL AND TILL		NA			1,000,000	
		SILT, PEAT AND ASH		NA				
		LOWER SALMON SPRINGS GRAVEL AND TILL		NA				
		-----		-----				
		-----		-----				
	EARLY	PUYALLUP FORMATION (INTERGLACIAL)		130				
STUCK DRIFT		NA						
ALDERTON FORMATION (INTERGLACIAL)		25						
ORTING DRIFT		200						
						2,000,000(?)		

2,000,000(?)

NA - NOT AVAILABLE

FIGURE 4-2

GENERALIZED STRATIGRAPHIC
COLUMN FOR THE PUGET
SOUND LOWLANDS
143rd CCSQ, Seattle ANG
Seattle, Washington



60324-02.DWG

The fill material is consistent with the descriptions of the material used to raise the Duwamish Valley for development in the 1910s. The second unit consists primarily of well-sorted, fine grained sand present from approximately 8 feet bgs to the maximum depth explored at the Station during the PA/SI and RI (21.5 feet bgs). Figure 4-3 shows the locations of geologic cross-sections through the IRP site; geologic cross-sections are presented on Figures 4-4 and 4-5.

4.4 Soils

The United States Department of Agriculture classified the soil underlying the Seattle ANGS as unclassified urban land. Urban land is soil that has been modified by the disturbance of the natural layers with additions of fill material several feet thick to accommodate large industrial and housing installations. In the Duwamish River Valley, the fill ranges from about 3 feet to more than 12 feet thick, and from gravelly sandy loam to gravelly loam in texture. The erosion hazard is slight to moderate (OpTech, 1995).

Two soil borings were drilled at the Seattle ANGS and five Dutch cone penetrometer samples were analyzed by Hart Crowser and Associates, Inc., during soil studies conducted at the Station in 1974 and 1982. Sandy silt to silty sand was the most common sediment within the uppermost 10 feet of unconsolidated sediments. Sand, with occasional thin silty layers, was the predominant lithology encountered from a depth of 10 to 50 feet bgs (OpTech, 1995).

4.5 Surface Water Hydrology

The Seattle ANGS is located approximately one-quarter mile from the main channel of the Duwamish Waterway, a major surface water drainage for western Washington. Between 1917 and 1919, the meanders of the Duwamish River within Seattle City limits were filled in and the Duwamish Waterway was formed. The western end of the meander near Boeing North Field was not filled in, and this portion of the Waterway became the present-day Slip No. 4.

The Federal Emergency Management Agency reported the drainage basin of the Duwamish as 450 square miles. The drainage basin is comprised of the Duwamish and Green Rivers.

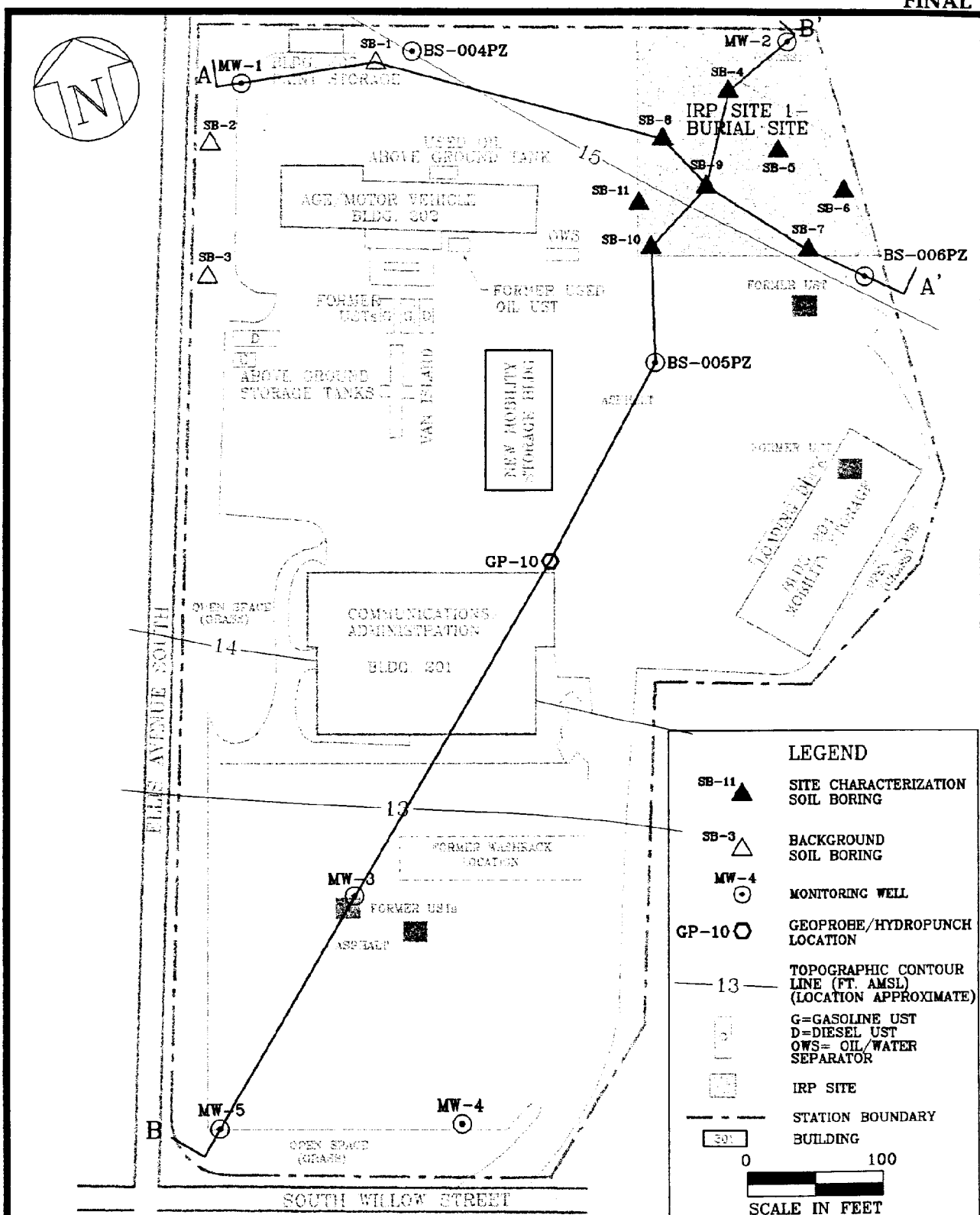


FIGURE 4-3

GEOLOGIC CROSS-SECTION
LOCATION MAP
143rd CCSQ, Seattle ANG
Seattle, Washington



80324-03.DWG

NORTHWEST
A

SOUTHEAST
A'

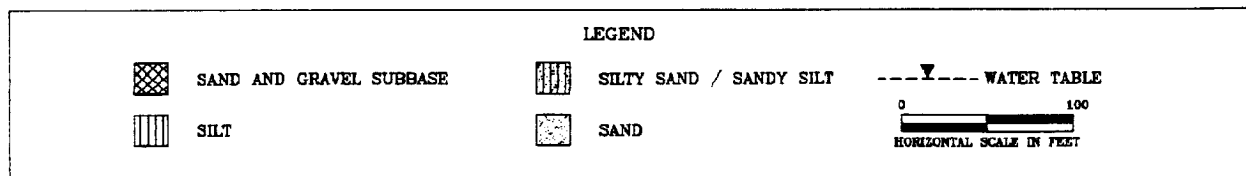
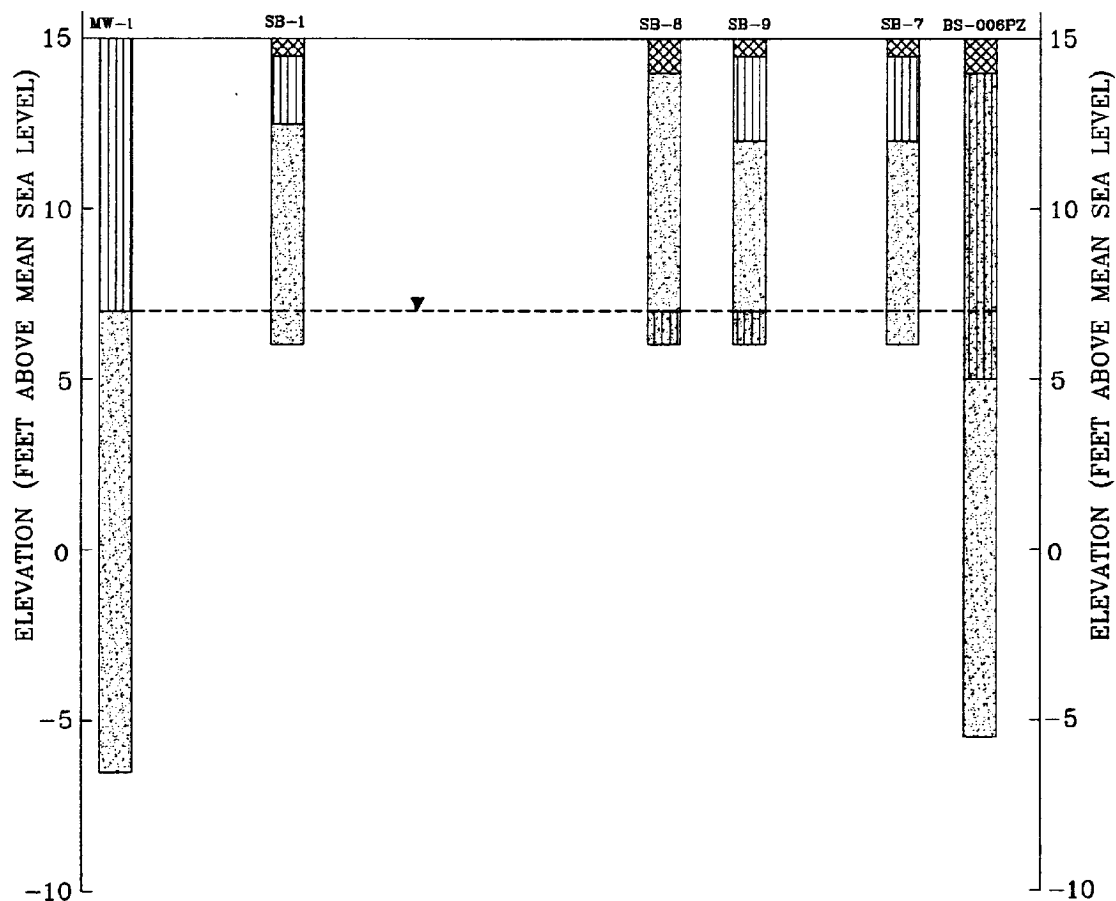


FIGURE 4-4

GEOLOGIC CROSS-SECTION A-A'

143rd CCSQ, Seattle ANG
Seattle, Washington



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SEA407465

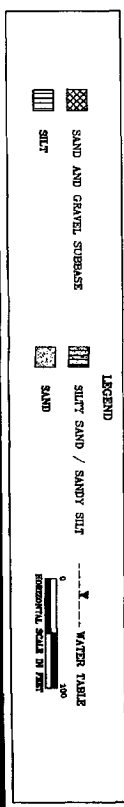
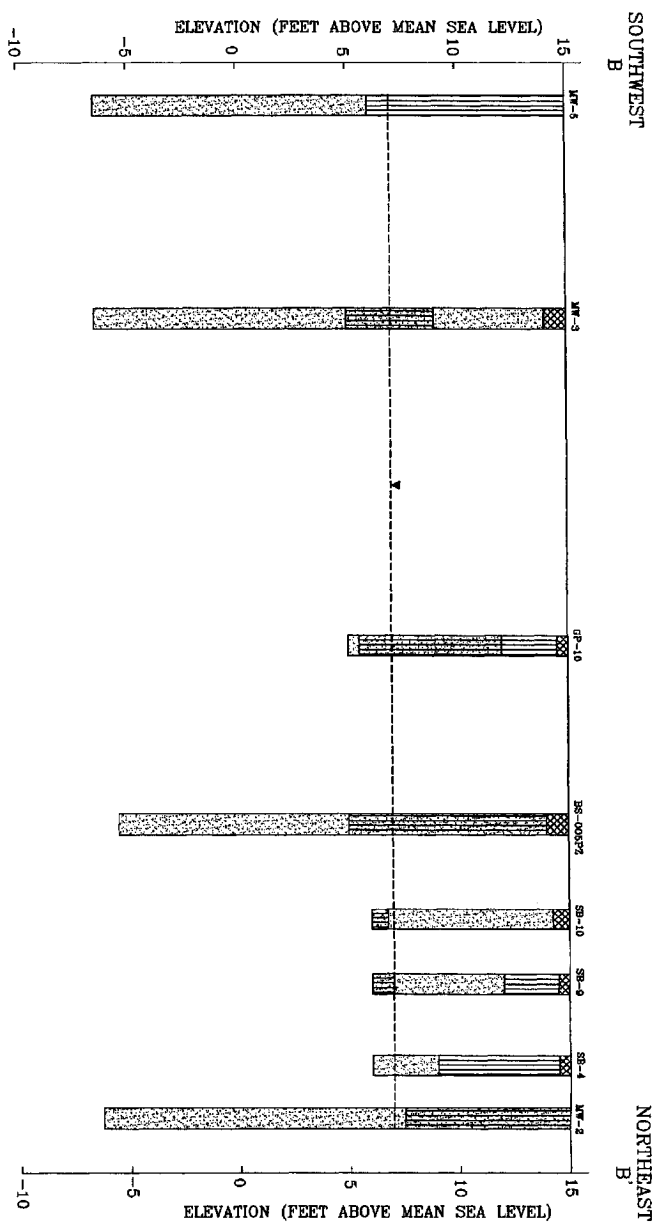


FIGURE 4-5

GEOLOGIC CROSS-SECTION B-B'

143rd CCSQ, Seattle ANGCS

Seattle, Washington

60251-05.DWG



Approximately 5.5 miles downstream (north) of the Station, the Duwamish discharges into Elliot Bay on the Puget Sound.

The Duwamish Waterway is the only fresh water body downgradient of the Station. The Seattle Water Department indicated that the Duwamish Waterway is not used for drinking water (OpTech, 1995). Surface water runoff at the Seattle ANGS flows into a series of catch basins that are tied into the municipal storm sewer. Figure 4-6 illustrates the storm drain system at the Station.

4.6 Hydrogeology

This section describes the regional and local hydrogeology in the vicinity of the Seattle ANGS, and summarizes the hydrogeologic conditions encountered at the Station during the Phase I RI.

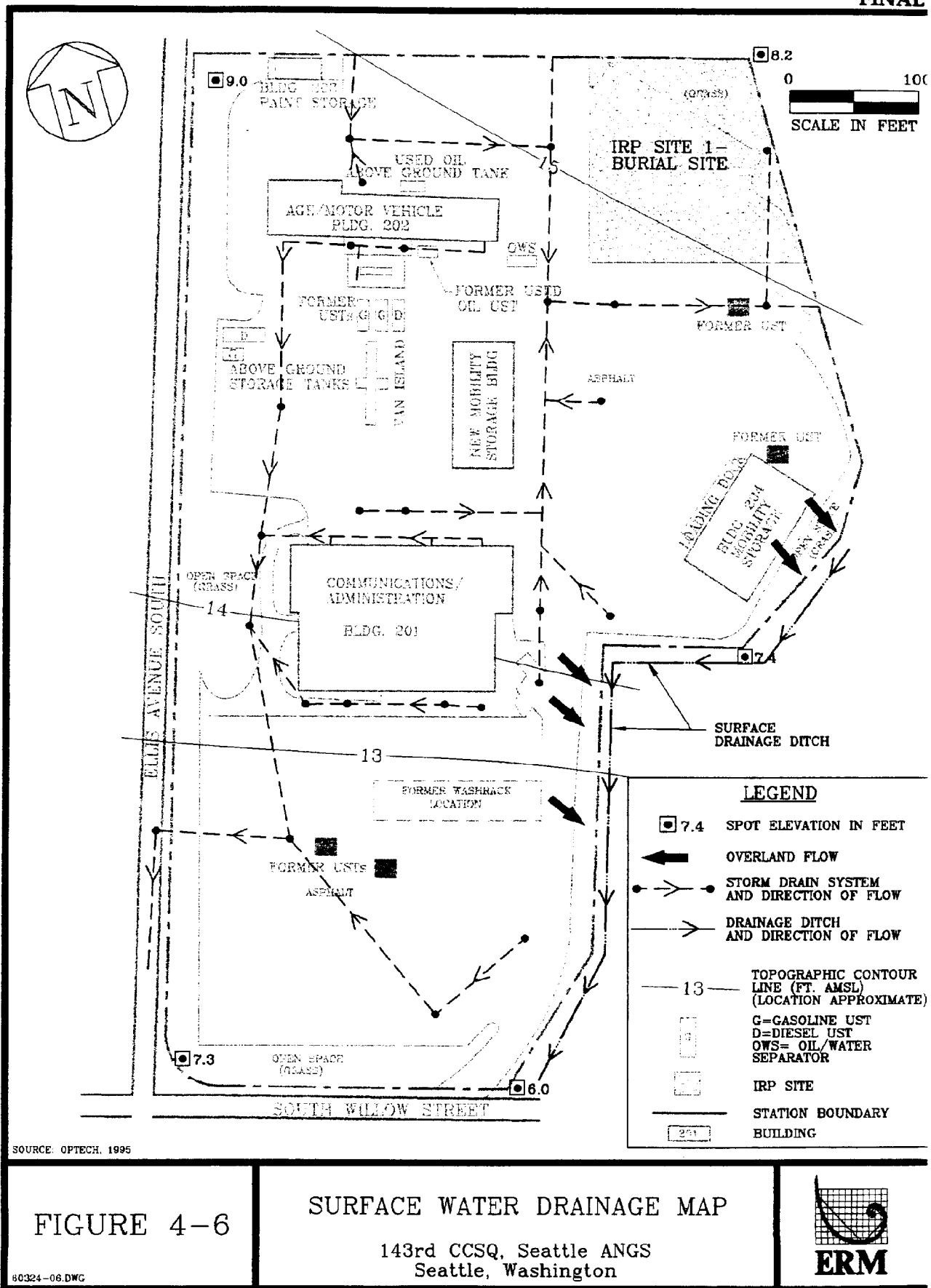
4.6.1 Regional Hydrogeology

Groundwater in the Duwamish River Valley occurs in two lithostratigraphic units. Shallow groundwater is present within a river alluvium unit. This unit underlies the Seattle ANGS and is described in the following section. Deeper groundwater reportedly exists beneath the river alluvium unit in unconsolidated glacial deposits (Luzier, 1969). Characteristics of this deeper aquifer are unknown; groundwater probably flows toward the Duwamish River and thus to Elliot Bay within the deeper aquifer (OpTech, 1995).

The Seattle Water Department has no municipal wells within 4 miles of the Station, and records obtained from the WDOE indicate that there are no private drinking water wells within a 1-mile radius of the Station. The surrounding population obtains drinking water from municipal water (OpTech, 1995).

The EDR environmental database report prepared as part of the Phase I RI/FS Work Plan presents data regarding water supply wells in the USEPA's database and wells included in the United States Geological Survey's database. All of the wells identified in the EDR report were greater than 1 mile from the Seattle ANGS (ERM, 1996).

The PA/SI report identified wells located within a 4-mile radius of the Seattle ANGS.



The wells were identified based on a review of State records. Construction details, use, and ownership information for the wells identified during the PA/SI are summarized in OpTech (1995).

4.6.2 Local Hydrogeology

Unconfined groundwater generally occurs at depths of 4 to 11 feet bgs in the vicinity of the Seattle ANGS, within the upper part of the recent river alluvium. Previous investigations in the area have found that groundwater is influenced by seasonal precipitation and tidal fluctuations. Groundwater flow in the vicinity of the Station is generally to the west, southwest, and south, toward the Duwamish Waterway, at a gradient of approximately 0.002 feet per foot (OpTech, 1995).

4.6.3 Site Hydrogeologic Conditions

Hydrogeologic data collected during the Phase I RI indicate that unconfined groundwater exists at depths of 6 to 10 feet bgs at the Seattle ANGS. The inferred groundwater flow direction is to the south. Representative potentiometric surface maps generated from the Phase I RI groundwater elevation data are shown on Figures 4-7 and 4-8. As shown on Figures 4-7 and 4-8, groundwater at the Station responds quickly to seasonal precipitation during the wet season; groundwater elevations increased approximately 2 feet between October 1996 and January 1997.

Slug tests were performed on monitoring well MW-3 during the Phase I RI. Hydraulic conductivity estimates ranging from 1.25×10^{-4} to 6.09×10^{-4} feet per second were calculated for monitoring well MW-3. These results are consistent with the predominant sand lithology encountered during well drilling.

4.7 Critical Habitats and Endangered/Threatened Species

No critical habitats or endangered or threatened species have been identified within 4 miles of the Seattle ANGS (OpTech, 1995).

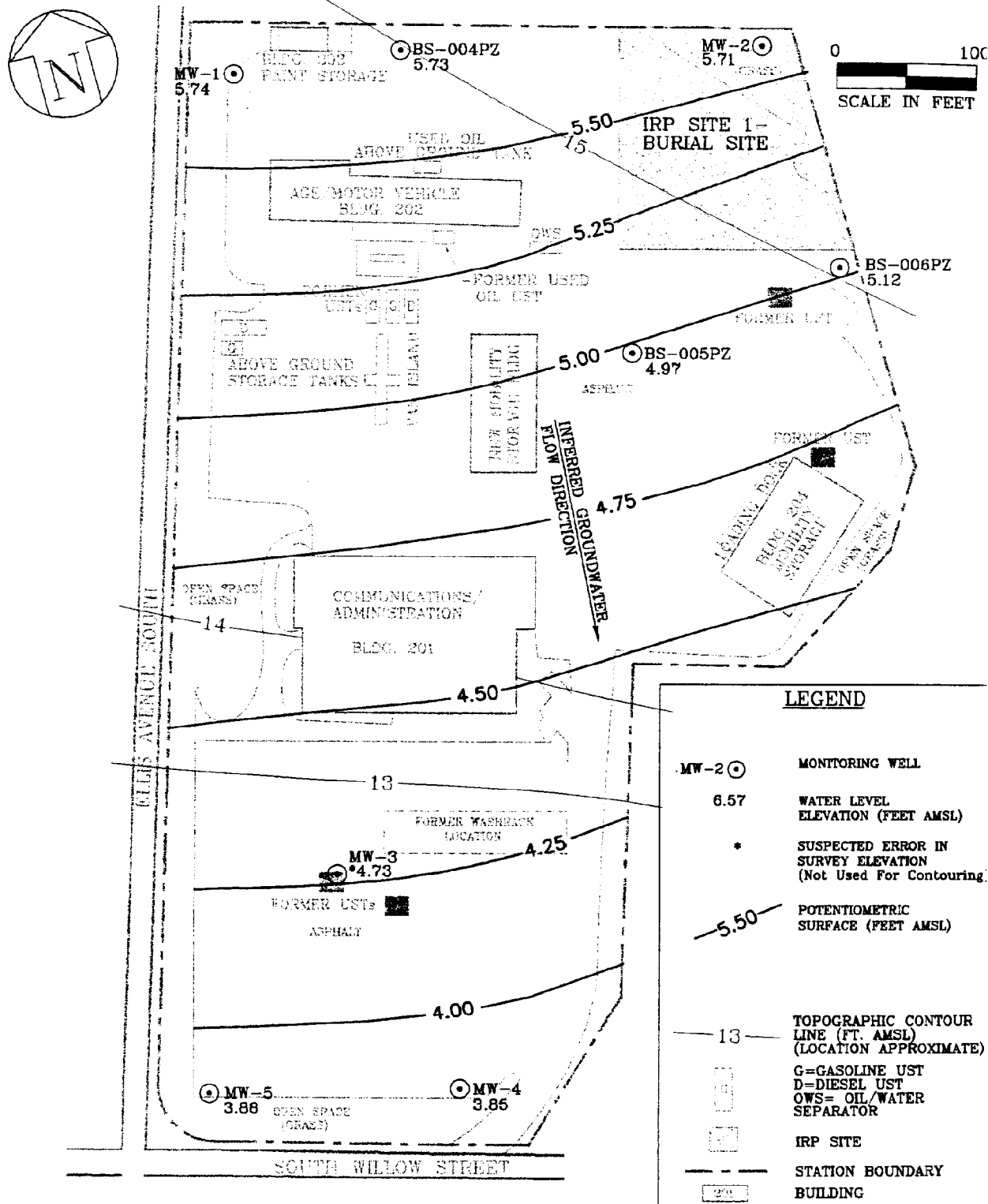


FIGURE 4-7

POTENTIOMETRIC SURFACE
OCTOBER 22, 1996

143rd CCSQ, Seattle ANG
Seattle, Washington



60324-07.DWG

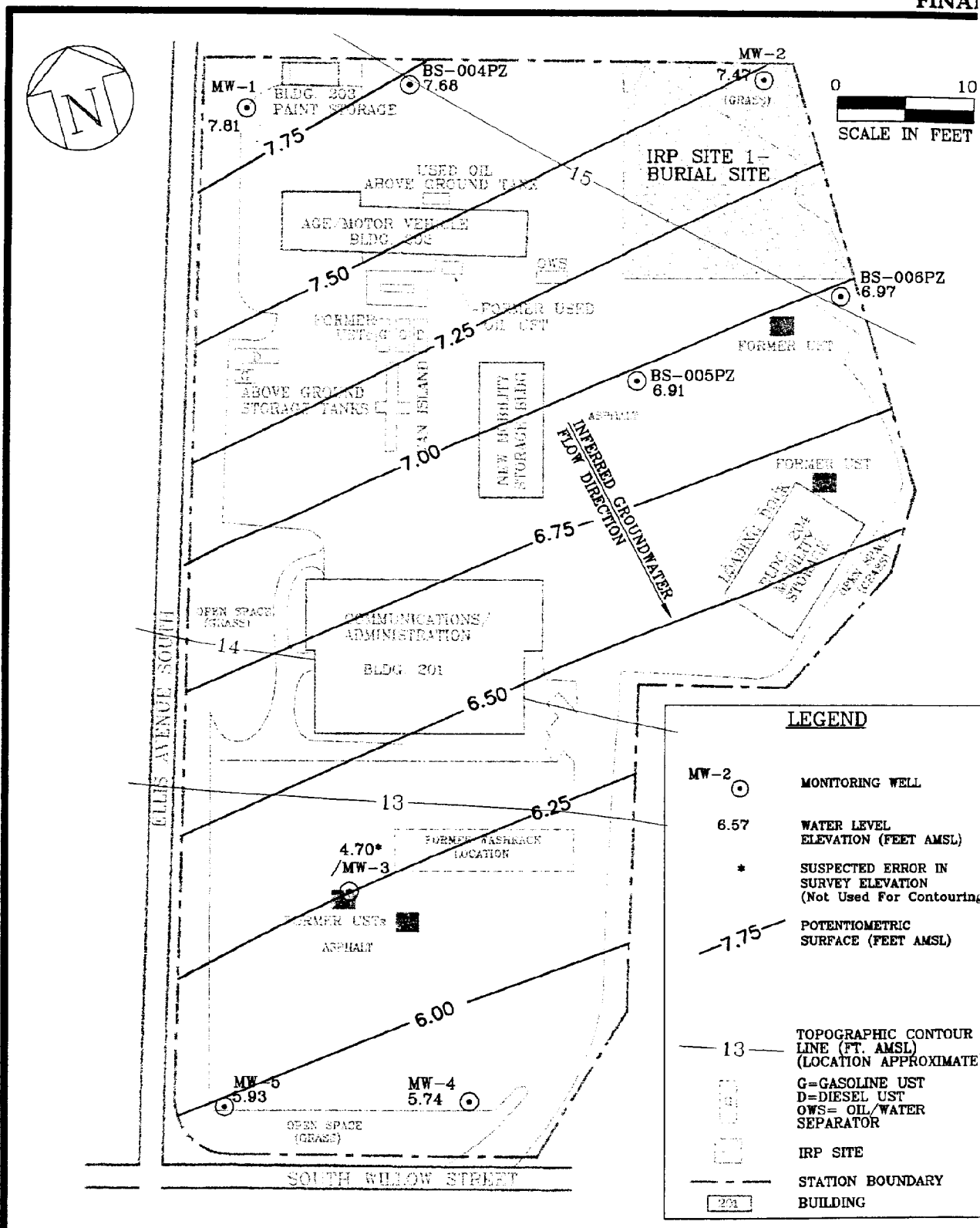


FIGURE 4-8

POTENTIOMETRIC SURFACE
JANUARY 14-15, 1997

143rd CCSQ, Seattle ANG
Seattle, Washington



80324-08 DWG

SECTION 5.0

PERMITS

The installation of groundwater monitoring wells during the Phase II RI will require submittal of a Notice of Intent to Construct a Monitoring/Resource Protection Well to the WDOE at least 3 days prior to commencing work at the site. This notice will be submitted by the drilling subcontractor. No other Federal, State, or local permits or notices are required for the planned Phase II RI field activities described in this Work Plan. Field work will be scheduled and coordinated with the ANG Project Manager, the local ANG Environmental Coordinator, and Seattle ANGS personnel.

Digging permits may be required by the Station prior to drilling or direct-push sampling activities on Station property, to ensure that adequate precautions have been taken to protect underground utilities. If required, these permits will be submitted for Station approval prior to mobilizing the drilling/direct-push subcontractor to the site.

SECTION 6.0

INVESTIGATIVE APPROACH

The Phase II RI will be conducted at the Seattle ANGS to further define the nature and extent of contamination at the Station. Both soil and groundwater investigations will be performed at the Station. The goals of the Phase II RI field investigation are to:

- Determine the source and extent of VOC contamination in soil and groundwater at the Station; and
- Determine trends in the concentrations of VOCs in groundwater and evaluate compliance with ARARs.

6.1 General Approach

The Phase II RI field investigation will consist of the following tasks: direct-push sampling of soil vapor, soil, and shallow groundwater; installation of new groundwater monitoring wells and quarterly sampling of new and existing monitoring wells; and analytical testing of collected samples. The sampling activities will be conducted during three separate field mobilizations. Soil vapor sampling will be conducted during the first mobilization, followed by Geoprobe/HydroPunch soil and groundwater sampling, followed by installation and sampling of groundwater monitoring wells. This phased approach will facilitate the selection of final soil and groundwater sampling/monitoring locations during the second and third mobilizations based on the analytical results obtained from the first and second mobilizations, respectively. The components of the Phase II RI field program are outlined below and summarized on Table 6-1.

FINAL

TABLE 6-1
Phase II Remedial Investigation Field Program
143rd CCSQ, Seattle ANG, Seattle, Washington

Sampling Location (1)	Sample Type	Estimated Number of Samples (2)	Purpose
SVS-1 through SVS-40	Soil Vapor	40	Identify potential source(s) of VOCs and determine final Geoprobe/HydroPunch sampling locations.
GP-23 through GP-42	Geoprobe/ HydroPunch Soil and Groundwater	20 Soil 20 Groundwater	Characterize potential source(s) and extent of VOCs in soil and shallow groundwater, and determine final groundwater monitoring well locations.
GP-23 through GP-25	Geoprobe/ HydroPunch Soil	3 Soil	Determine lateral extent of TPH in soil surrounding PA/SI soil boring BS-003BH.
BS-004PZ through BS-006PZ; MW-1 through MW-10	Groundwater	52*	Determine extent and trends in concentrations of VOCs in groundwater; assess compliance with ARARs.

* = Total number of groundwater samples to be collected at quarterly intervals over a one-year period at the locations indicated.

(1) See Figures 6-1 and 6-2 for sampling locations.

(2) Number of samples shown does not include field QA/QC samples.

6-2

6.2 Field Investigation Activities

This section summarizes the field investigation activities that will be performed during the Seattle ANGS Phase II RI.

6.2.1 Soil Vapor Sampling

Soil vapor samples will be collected from 40 locations to screen for potential sources of VOCs in soil. The soil vapor survey will focus on the northwest and southern portions of the Station, where VOCs were previously detected in groundwater at concentrations above ARARs. The planned locations of the soil vapor samples are shown on Figure 6-1. The soil vapor samples will be collected from approximately 5 feet bgs, and will be analyzed in a mobile field laboratory for VOCs.

6.2.2 Geoprobe/HydroPunch Soil and Groundwater Sampling

Geoprobe/HydroPunch subsurface soil and groundwater samples will be collected from 20 locations to characterize the extent and potential sources of VOCs in soil and shallow groundwater. The Geoprobe/HydroPunch sampling results will also be utilized to assess potential on-Station transport of VOCs from off-Station sources, and the soil samples will provide additional subsurface lithologic data. Preliminary locations of the Geoprobe/HydroPunch samples are shown on Figure 6-2. Final sampling locations will be determined based on the soil vapor survey results. Soil samples will be collected from just above the water table, and will be analyzed at an off-site State-certified laboratory for VOCs. Groundwater samples will be collected from approximately 2.5 feet below the water table, and will be analyzed in a mobile field laboratory for VOCs.

Three of the Geoprobe/HydroPunch sampling locations (GP-23 through GP-25) are predetermined. Soil samples collected from these locations will be analyzed for TPH in addition to VOCs. The soil TPH results will be used to constrain the lateral extent of TPH contamination detected above ARARs at PA/SI soil boring location BS-003BH (see Table 3-1).

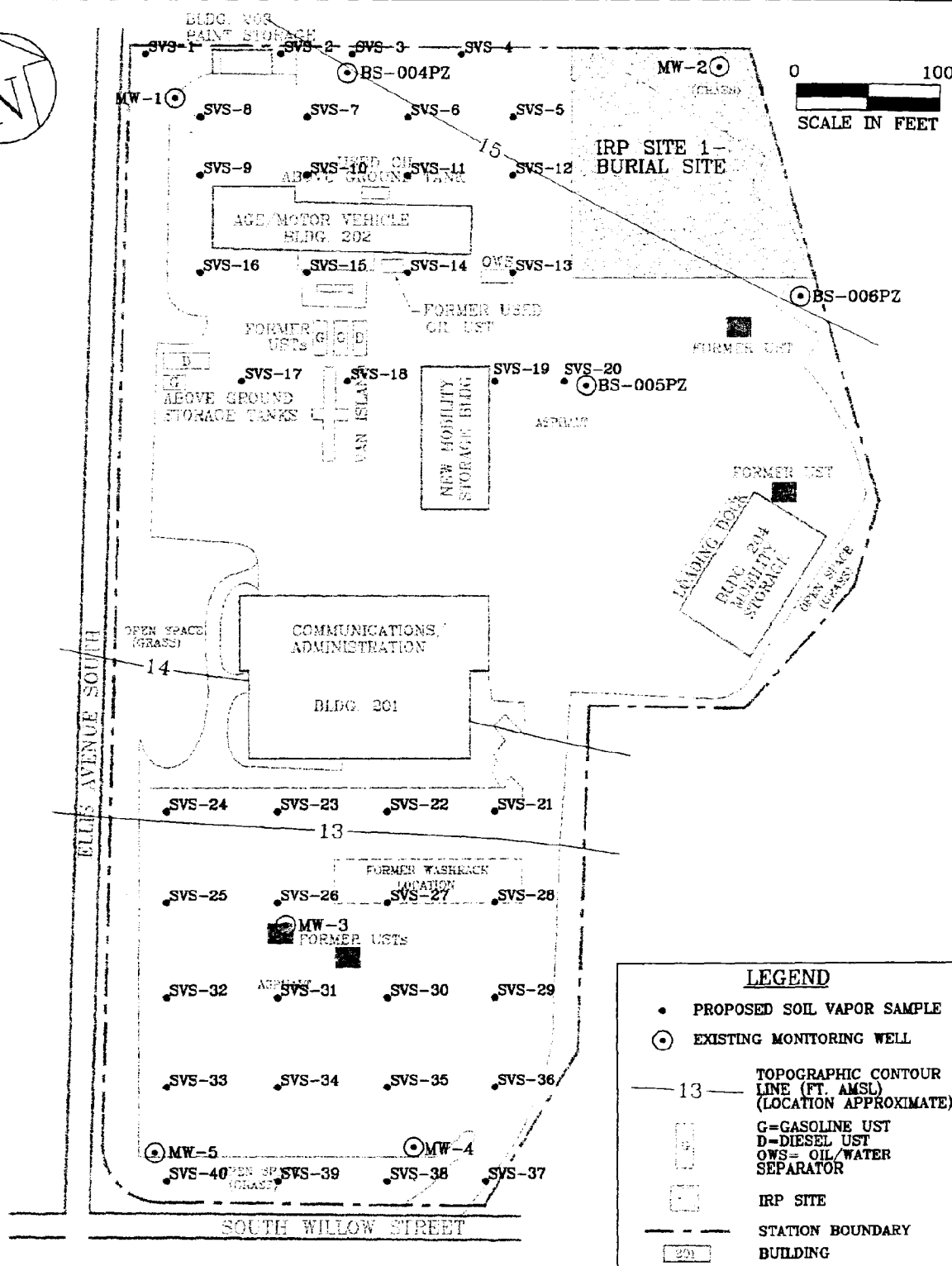


FIGURE 6-1

PROPOSED SOIL VAPOR SAMPLING LOCATIONS

143rd CCSQ, Seattle ANG
Seattle, Washington



60326-01.DWG

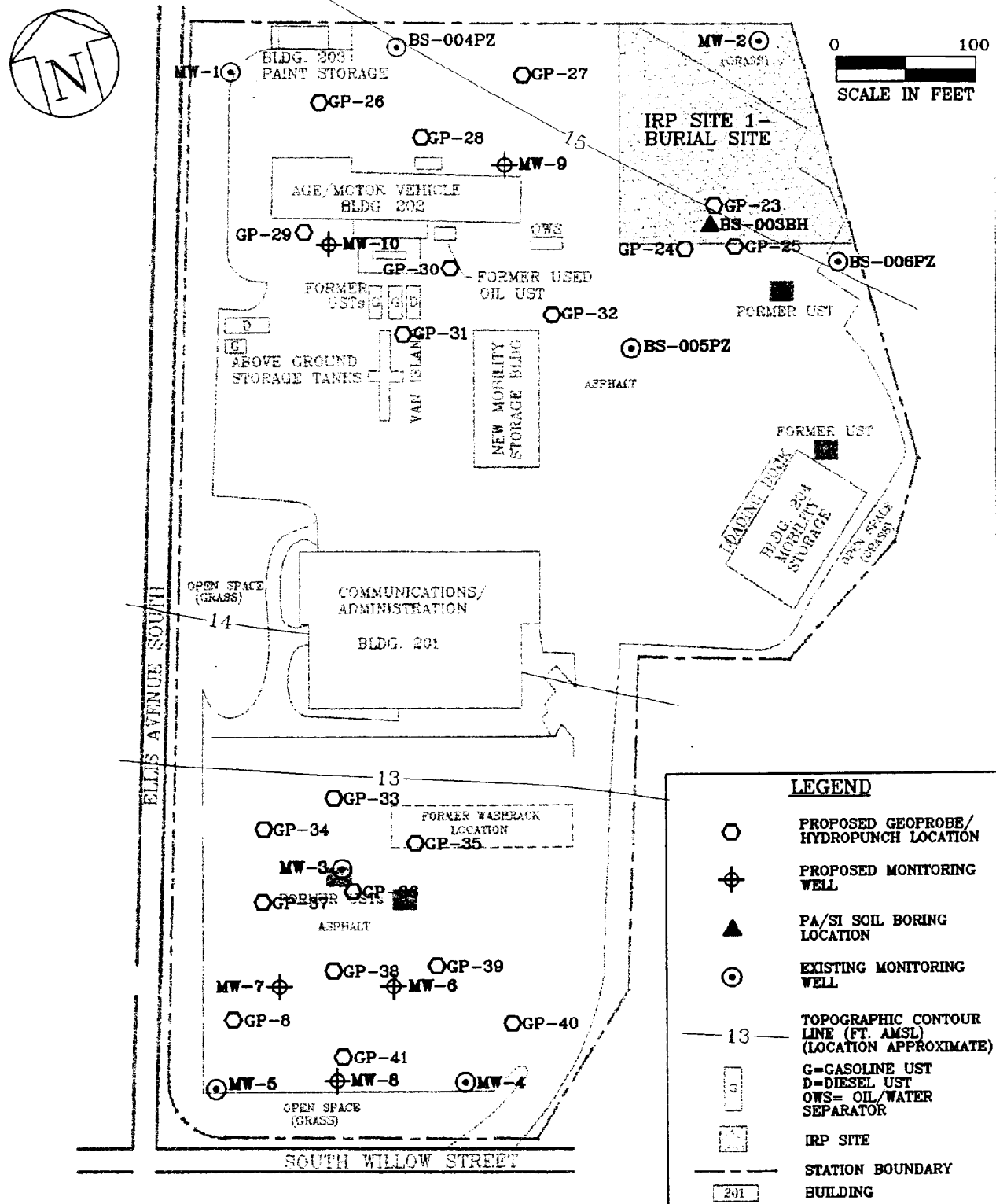


FIGURE 6-2

PROPOSED GEOPROBE/HYDROPUNCH AND MONITORING WELL LOCATIONS

143rd CCSQ, Seattle ANG
Seattle, Washington



60328-02.DWG

KCSlip4 40947

SEA407477

6.2.3 Groundwater Monitoring Well Installation

Five new groundwater monitoring wells will be installed to further define the lateral extent of VOCs in shallow groundwater and to monitor compliance of VOC concentrations with ARARs. Preliminary locations of the new monitoring wells are shown on Figure 6-2. Final monitoring well locations will be determined based on the results of the Geoprobe/HydroPunch sampling. The target depth of the monitoring wells is 20 feet bgs; the screened interval will extend from approximately 5 feet bgs to 20 feet bgs.

The monitoring wells will be constructed similar to the monitoring wells installed during the PA/SI and Phase I RI to allow collection of comparable groundwater quality data.

6.2.4 Groundwater Monitoring

The new and existing groundwater monitoring wells at the Station (13 wells total) will be sampled during four quarterly monitoring events. The groundwater samples will be analyzed at an off-site State-certified laboratory for VOCs.

6.2.5 Analytical Methods

Samples collected during Phase II RI field activities will be analyzed in accordance with USEPA analytical protocols published in *Test Methods for Evaluating Solid Wastes (SW-846)* and Washington State TPH analytical protocols published by the WDOE. Analytical methods to be used are summarized on Table 6-2. Further details regarding quantitation limits and QA/QC for laboratory analyses are discussed in the RI/FS QAPP contained in Appendix B.

6.3 Deviations from the Work Plan

Any significant deviations from the activities, procedures, or analyses performed pursuant to this Work Plan will be discussed and approved in advance with the ANG Project Manager. A description of any such deviations will be included in the Phase II RI/FS report.

FINAL

TABLE 6-2
Phase II RI Field and Laboratory Testing Plan
143rd CCSQ, Seattle ANG, Seattle, Washington

Matrix	Sampling Method	Field Parameters	Laboratory Parameters	Analytical Method	Estimated No. Primary Sample Analyses	Estimated No. Field QA/QC Sample Analyses					Total Laboratory Analyses
						Trip Blank	Rinsate Blank	Field Blank	Field DUP	MS/MSD	
Soil Vapor	Geoprobe - 40 locations	None	VOCs	USEPA 8010/8020	40		4	4	4		52
Soil	Geoprobe - 20 locations	Organic vapors	VOCs	USEPA 8260	20	2	2	2	2	1	29
			TPH	WTPH-HCID	3		1	1	1		6
Groundwater	HydroPunch - 20 locations	None	VOCs	USEPA 8010/8020	20		2	2	2	1	27
	8 existing MWs, 5 new MWs, quarterly for 1 year	S.C., Turbidity, pH, Temperature	VOCs	USEPA 8260	52	4	5	5	5	3	74

VOCs = Volatile organic compounds
 TPH = Total petroleum hydrocarbons
 WTPH-HCID = Washington TPH - hydrocarbon identification method
 QA/QC = Quality assurance/quality control
 DUP = Duplicate sample
 S.C. = Specific conductance

USEPA = United States Environmental Protection Agency
 MS/MSD = Matrix spike/matrix spike duplicate
 MW = Monitoring well

6-7

SECTION 7.0

FIELD INVESTIGATION PROCEDURES**7.1 Soil Vapor Sampling**

Prior to the start of the soil vapor survey, the locations of underground utilities in the vicinity of the sampling points will be reviewed and marked as necessary, and any required Station digging permits will be completed and submitted to the appropriate Station personnel for approval. Any planned sampling points found to interfere with buried utilities will be relocated as close as possible to the original location. If any soil vapor sampling point needs to be relocated greater than 5 feet from the original location, the new location must be approved by the ANG Project Manager or designated representative. The planned sampling points will be clearly marked in the field for inspection and approval by Station personnel.

7.1.1 Sample Collection

One soil vapor sample will be collected from each designated location by hydraulically pushing a slotted stainless-steel drive point into the soil to a depth of approximately 5 feet bgs. Slots near the tip of the drive point will be exposed by retracting the outer steel sampling probe a few inches. A vacuum pump will then be used to purge approximately five volumes of air from the sampling probe and extract soil vapors. The soil vapor samples will be collected from the sampling probe using a syringe and will be transferred to canisters, sample bags, or volatile organics analysis (VOA) vials for subsequent analysis in the on-site mobile field laboratory. Immediately after sample collection, soil vapors present in the sampling probe will be screened for organic vapors using a photoionization detector (PID). The soil vapor samples will be analyzed in accordance with the analytical testing plan outlined on Table 6-2.

7.1.2 Borehole Abandonment

After the required samples have been collected from each soil vapor boring, the boring will be abandoned by grouting. Grout will be introduced by a tremie pipe into the bottom of the open borehole and filled to the surface. The grout will be mixed in the approximate ratio of one sack (94 pounds) of Portland cement to 5 pounds of powdered bentonite to 8 gallons of water. The bentonite powder and water will be mixed prior to the addition of the cement.

Following completion of the soil vapor survey, the site will be restored as closely as possible to its pre-investigation condition.

7.2 Geoprobe/HydroPunch Soil and Groundwater Sampling

Prior to the start of the Geoprobe/HydroPunch sampling, the locations of underground utilities in the vicinity of the planned sampling points will be reviewed and marked, and sampling points will be relocated as necessary as described in Section 7.1. After sampling activities are completed, the sampling points will again be clearly marked to facilitate subsequent surveying.

7.2.1 Sample Collection

Subsurface soil samples will be collected using a stainless-steel Geoprobe drive sampler (or similar equipment). The drive sampler will be lined with stainless-steel or brass sample tubes. One soil sample will be collected from each designated location from just above the water table (approximately 5 to 10 feet bgs). A portion of each soil sample collected will be field-screened for organic vapors using a PID. A portion of each soil sample will also be used for lithologic description. The remaining undisturbed portion of each soil sample will be submitted to an off-site State-certified laboratory for analytical testing in accordance with the analytical testing plan outlined on Table 6-2.

Groundwater samples will be collected using a HydroPunch groundwater sampling device (or similar equipment) comprised of a stainless-steel drive point, a perforated section of stainless-steel pipe for sample intake, and a stainless-steel and Teflon sample chamber. One groundwater sample will be collected from each designated location from approximately 2.5 feet below the water table. The groundwater samples will be transferred to VOA vials for subsequent analysis in the on-site

mobile field laboratory. The groundwater samples will be analyzed in accordance with the analytical testing plan outlined on Table 6-2.

7.2.2 Sample Logging

An experienced geologist will be present at the Geoprobe rig to monitor direct-push sampling operations, log soil and groundwater samples, field-screen soil samples, and record subsurface hydrogeologic conditions encountered. The geologist will have sufficient tools and professional equipment in operable condition to efficiently perform these duties.

The lithologic descriptions of soil samples recorded by the geologist will be based on visual inspection of the soil samples collected. Material will be classified using the Unified Soil Classification System and described according to American Society for Testing and Materials (ASTM) D2488-69, "Description of Soils (Visual Manual Procedure)."

The following information will be recorded on the sample logs:

- Sample types and quantities;
- Sample identification numbers;
- Sampling depths and reference points for depth measurements;
- Soil sample PID readings;
- Soil sample descriptions, including soil moisture/saturation conditions;
- Weather conditions;
- Name of Geoprobe/HydroPunch operator and attendant geologist; and
- Signature of attendant geologist.

7.2.3 Borehole Abandonment

After the required samples have been collected from each Geoprobe/HydroPunch boring, the boring will be abandoned by grouting as described in Section 7.1.2. Following completion of the Geoprobe/HydroPunch sampling, the site will be restored as closely as possible to its pre-investigation condition.

7.3 Field Screening

As indicated in Section 7.2.1, soil samples collected from Geoprobe/HydroPunch sampling locations will be field-screened for organic vapors using a PID. The following procedure will be used to field-screen soil samples. First, a portion of each soil sample will be placed in either a re-sealable plastic bag or a clean glass sample jar. The plastic bag will be immediately sealed or the mouth of the glass jar covered with aluminum foil. The sample will then be gently agitated for approximately 30 seconds and left to equilibrate at ambient temperature (out of direct sunlight) for at least 15 minutes. Following the equilibration period, the total organic vapor concentration of the soil sample will be measured by carefully pushing the PID probe through the wall of the plastic bag or through the aluminum foil into the headspace above the sample. The maximum PID reading observed for each sample will be recorded in field notes.

7.4 Monitoring Well Installation

Prior to the start of drilling, the locations of underground utilities in the vicinity of the planned monitoring wells will be reviewed and marked, and the monitoring wells will be relocated as necessary as described in Section 7.1.

7.4.1 Drilling Procedures and Borehole Logging

Monitoring well borings will be drilled by a State-licensed well driller. The borings will be drilled to an approximate depth of 20 feet bgs using hollow-stem auger methods. An experienced geologist will be present at the drilling rig to monitor drilling and well installation operations, conduct air monitoring with a PID, record geologic and hydrogeologic information on boring logs, and document monitoring well construction. The geologist will have sufficient tools and professional equipment in operable condition to efficiently perform these duties.

Lithologic descriptions recorded by the geologist on the boring logs will be based on visual inspection of the drill cuttings. Material will be classified using the Unified Soil Classification System and described according to ASTM D2488-69, "Description of Soils (Visual Manual Procedure)."

The following information will be recorded on the boring log for each monitoring well:

- Monitoring well identification number;
- Monitoring well location and approximate ground surface elevation;
- Name of drilling company, driller, and attendant geologist;
- Method of drilling;
- Borehole diameter;
- Air monitoring results;
- Lithologic descriptions and PID readings for soils encountered, including soil moisture/saturation conditions and corresponding drilling depths;
- Depth at which saturated soil/groundwater is first encountered while drilling;
- Total depth of completed borehole;
- Reference elevation for all depth measurements;
- Monitoring well construction details;
- Weather conditions; and
- Signature of attendant geologist.

7.4.2 Monitoring Well Construction

The groundwater monitoring wells will be constructed in accordance with applicable State well standards and requirements (Chapter 173-360 Washington Administrative Code [WAC]; Chapter 18.104 Revised Code of Washington). Figure 7-1 shows the proposed construction of the monitoring wells. The monitoring wells will be constructed of threaded, flush-joint, 2-inch Schedule 40 polyvinyl chloride (PVC) casing. The well screen will consist of 0.010-inch slotted PVC casing. The screened interval will extend from approximately 5 feet above the water table to 10 feet below the water table.

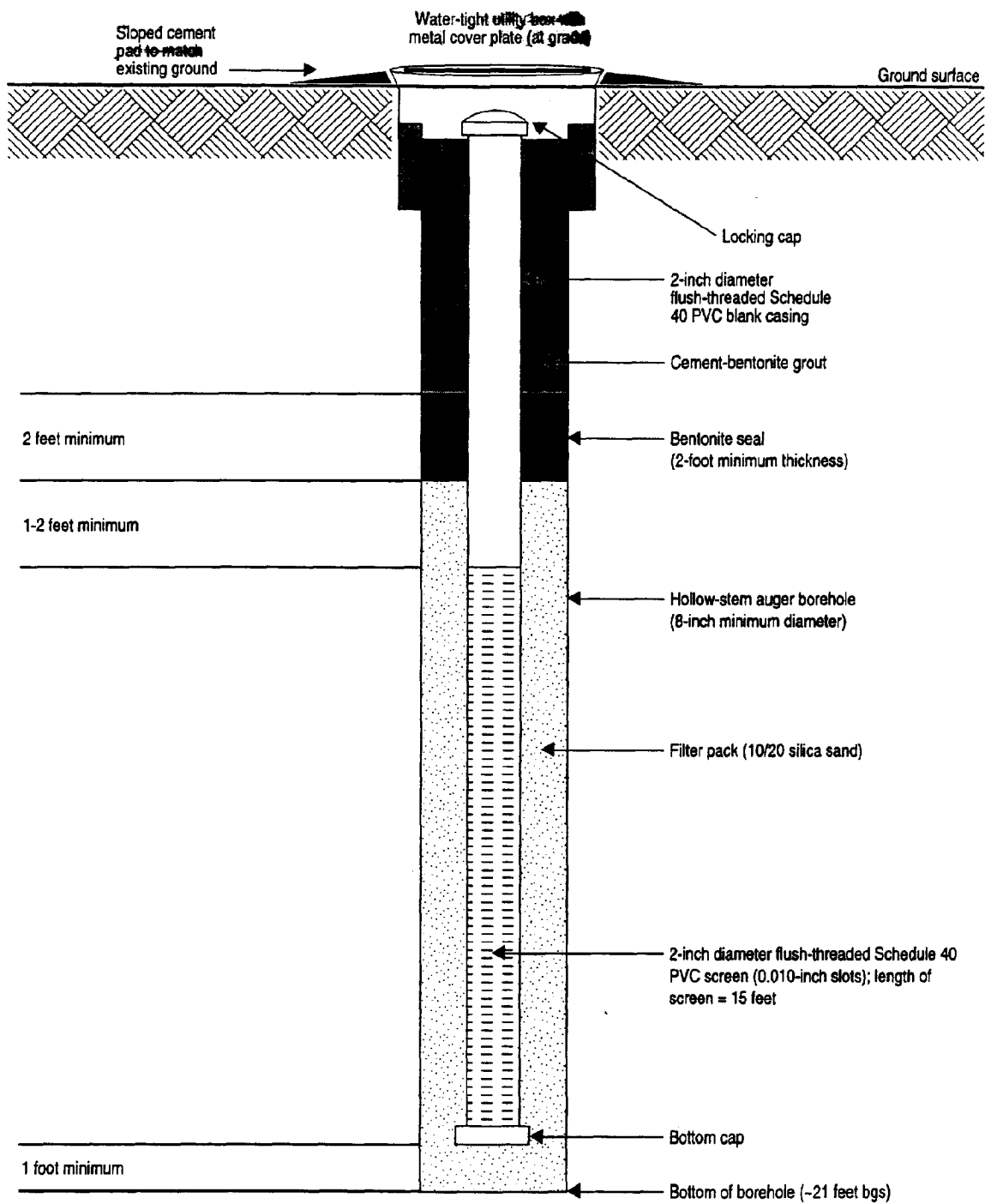


FIGURE 7-1

04.24.98/HML/6051.21

**PROPOSED MONITORING WELL
CONSTRUCTION**

143rd CCSQ, Seattle ANG
Seattle, Washington



The annular space between the well screen and the borehole wall will be backfilled with clean 10/20 silica sand installed to 1 to 2 feet above the top of the well screen. A bentonite slurry seal (2 feet minimum thickness) will be installed above the sand pack using a tremie pipe. The remaining annular space will be grouted to within 2 feet of the ground surface using a cement-bentonite mixture.

A performance test consisting of lowering a clean weighted sampling bailer to the bottom of the well will be conducted after the annular space is completely backfilled, to ensure that the monitoring well is straight and has not collapsed.

The monitoring wells will be completed at grade with a traffic-rated steel or aluminum monitoring well monument set in concrete. The monument will be raised slightly above the ground surface and the concrete surface seal will be sloped away from the monument to minimize collection of surface water runoff inside the monument. A lockable compression cap will be installed on each monitoring well inside the monument.

7.4.3 Monitoring Well Development

The monitoring wells will be developed within 24 to 48 hours after well completion. Monitoring wells will be developed using either a submersible pump or a bailer. Monitoring well development will consist of repeated well purging and surging until the clarity of the water has stabilized.

The water level in each monitoring well will be measured before development begins. An electronic water level indicator, accurate to 0.01 feet, will be used to measure the depth to water from a prescribed reference point on the well casing.

A minimum of 10 well casing volumes will be purged and at least three times the volume of any potable water added during drilling will be removed during development. The temperature, pH, turbidity, and specific conductance of the purge water will be measured during well development. Well development will continue until these parameters have stabilized to within ± 10 percent. Field logs will be maintained during well development to document specific development methods and duration, water quality parameter measurements, and the amount of water removed from each monitoring well.

7.5 Groundwater Monitoring

Groundwater monitoring will be performed on a quarterly basis for 1 year. Water-level measurements will be taken and groundwater samples collected from the eight existing and five new monitoring wells during each quarterly monitoring event (13 wells total). During the first event, the eight existing wells installed during the PA/SI and Phase I RI will be sampled prior to the soil vapor survey, to establish the baseline groundwater quality at the start of Phase II RI field activities. The five new wells will be sampled approximately 4 weeks later following completion and development of these wells.

The monitoring wells will be purged prior to sampling using a submersible pump. Groundwater samples will be collected using a submersible pump or disposable sampling bailer. The groundwater samples will be submitted to an off-site State-certified laboratory for analytical testing in accordance with the analytical testing plan outlined on Table 6-2.

7.6 Equipment Decontamination Procedures

All non-dedicated, reusable sampling equipment will be decontaminated prior to use and between sample collection. ANG decontamination protocols call for washing sampling equipment with an aqueous solution of laboratory-grade detergent (e.g., Alconox) followed by a rinse with ASTM Type II reagent grade water (or equivalent) and pesticide-grade methanol. Decontaminated equipment will be wrapped in aluminum foil (shiny side outward) or otherwise stored or positioned to preclude inadvertent contamination prior to reuse.

Drilling equipment (e.g., drill rig and augers) will be decontaminated prior to use and between borings by steam cleaning in a designated decontamination area. The Site Manager is responsible for ensuring that the decontamination area is kept clean and orderly. All decontaminated equipment and unused construction materials will be removed from the site at the completion of field activities.

7.7 Documentation of Field Activities

The field geologist, and any other on-site ERM personnel performing support tasks not directly overseen by the field geologist, will maintain field notebooks during field activities. Each field notebook will be a weather-resistant, bound, survey-type field book and will be assigned a unique number. Field data generated during the investigation and any comments or other notes will be entered directly into the field notebooks.

In addition to written documentation recorded in field notebooks, field activities will be documented with photographs. Activities to be photographed include soil vapor sampling, Geoprobe/HydroPunch sampling, drilling and monitoring well installation, groundwater sampling, and equipment decontamination. Photographs will also be taken to document the clarity of each groundwater sample collected for laboratory analysis.

7.8 Land Surveying

The Geoprobe/HydroPunch sampling locations and the five new monitoring wells will be surveyed by a State-licensed surveyor to define their locations and surface elevations for future reference. The surveyed points will be established with a horizontal accuracy of ± 0.1 feet and a vertical accuracy of ± 0.01 feet. Vertical survey data will be based on the "Boeing G" benchmark with an elevation of 10.58 feet National Geodetic Vertical Datum of 1929. The position and coordinates of each permanent point within the control traverse will be documented.

SECTION 8.0

SAMPLE COLLECTION PROCEDURES

Procedures used to collect environmental samples will follow ERM's Standard Operating Procedures for IRP program work and will conform to ANG site investigation protocols. Standard Operating Procedures are included in Appendix B of ERM's Quality Assurance Program Plan for IRP work (ERM, 1995). The Site Manager is responsible for ensuring that samples are collected with properly decontaminated equipment and contained in proper sample containers with appropriate preservatives. The steps required for sample identification and control, data recording, and chain-of-custody documentation are described in the site-specific QAPP contained in Appendix B of this Work Plan.

8.1 Soil Vapor

Soil vapor samples will be collected from approximately 5 feet bgs using a hydraulically-driven sampling probe consisting of threaded sections of 1-inch diameter steel pipe. The sampling probe will be fitted with a detachable slotted stainless-steel drive point. After the sampling probe is advanced to the desired depth, the probe will be retracted to expose the slots on the drive point. A vacuum pump will then be used to purge approximately five volumes of air from the sampling probe and extract soil vapors. The soil vapor samples will be collected from the sampling probe using a disposable gas-tight syringe and will be transferred to canisters, sample bags, or VOA vials for subsequent analysis in the on-site mobile field laboratory. The sampling probe and drive point will be decontaminated before use at each new sampling location as described in Section 7.6.

8.2 Soil

Subsurface soil samples will be collected from just above the water table using the Geoprobe rig. Samples will be obtained by hydraulically pushing a 1-inch diameter stainless-steel drive sampler to the desired

sampling depth. The drive sampler will be lined with stainless-steel or brass sample tubes. Soil at shallower depths will be prevented from entering the drive sampler by a center steel rod. At the specified depth the center rod will be removed and the drive sampler will be pushed into undisturbed soil. The drive sampler will then be extracted and the lower-most or fullest sample tube will be immediately sealed using a Teflon barrier, aluminum foil (shiny side up), and a plastic end cap at each end of the tube. This sample will be designated for analysis at the off-site laboratory. One or more of the remaining sample tubes will be used for lithologic description and organic vapor screening with a PID. Equipment used during Geoprobe/HydroPunch sampling will be decontaminated before use at each new sampling location as described in Section 7.6.

8.3 Groundwater

Groundwater samples will be collected from Geoprobe/HydroPunch sampling locations and from monitoring wells. Sampling procedures for each are summarized below. Additional details regarding groundwater sampling procedures are provided in the QAPP (Appendix B).

8.3.1 Geoprobe/HydroPunch Procedures

A HydroPunch sampling device (or similar equipment) will be used to collect groundwater samples from the Geoprobe/HydroPunch sampling locations. The HydroPunch is comprised of a stainless-steel drive point, a perforated section of stainless-steel pipe for sample intake, and a stainless-steel and Teflon sample chamber. The Geoprobe rig will push the HydroPunch through the soil to the desired sampling depth (approximately 2.5 feet below the water table). The sampling probe will then be retracted, exposing the perforations and allowing groundwater to flow into the sample chamber. When the sample chamber is full the HydroPunch will be pulled to the surface and the drive point removed. A sample discharge device will then be inserted into the sample chamber to transfer the groundwater sample to VOA vials for subsequent analysis in the on-site mobile field laboratory. Equipment used during Geoprobe/HydroPunch sampling will be decontaminated before use at each new sampling location as described in Section 7.6.

8.3.2 Monitoring Well Procedures

Groundwater samples will be collected on a quarterly basis from the eight existing and five new monitoring wells. The wells will be purged and water-level measurements taken before each well is sampled. Monitoring wells will be purged using a non-dedicated submersible pump. Low-flow purging and sampling methods will be utilized to obtain representative groundwater samples while minimizing the amount of purge water generated. Groundwater samples will be collected either directly from the pump discharge or with single-use disposable polyethylene sampling bailers. Groundwater samples collected from monitoring wells will be analyzed at an off-site laboratory. Equipment used during monitoring well sampling will be decontaminated before use at each well as described in Section 7.6. The submersible pump and discharge hose will be decontaminated by circulating the detergent solution through the energized pump and hose for several minutes followed by a once-through rinse with ASTM Type II reagent grade water (or equivalent).

8.4 Field Quality Assurance/Quality Control (QA/QC) Samples

Field duplicate samples and equipment rinsate blanks, field blanks, and trip blanks will be submitted to the analytical laboratory to provide a means of assessing the quality of the data resulting from the field sampling program. Field duplicate samples will be analyzed to assess sample homogeneity. The duplicate samples will be submitted blind to the analytical laboratory (i.e., using non-indicative sample identifiers) to provide a QA check on analytical procedures and results. Rinsate, field, and trip blanks will be analyzed to check for potential contamination associated with sampling procedures, ambient conditions at the site, and/or sample packaging and transportation methods.

The estimated number and types of field QA/QC samples to be collected during the Phase II RI are summarized on Table 6-2. Additional details regarding field QA/QC procedures are provided in the QAPP (Appendix B).

SECTION 9.0

INVESTIGATION-DERIVED WASTE MANAGEMENT

Drill cuttings, purge water, and decontamination water generated during drilling and sampling activities will be contained in segregated 55-gallon drums. The investigation-derived waste (IDW) drums will be clearly marked with a description of the contents and the accumulation date. The contents of each IDW drum will be designated as hazardous/dangerous waste or non-hazardous/non-dangerous waste in accordance with Federal Resource Conservation and Recovery Act (RCRA) and Washington State Dangerous Waste Regulations. The waste designation will be based on the analytical results for soil and groundwater samples collected during the Phase II RI.

Purge water and decontamination water determined to be non-hazardous/non-dangerous will be either discharged to the sanitary sewer after obtaining approval from the local Publicly Owned Treatment Works or removed for off-site disposal by a licensed contractor. Drill cuttings determined to be non-hazardous/non-dangerous will be removed for off-site disposal by a licensed contractor.

Disposal of IDW determined to be hazardous or dangerous waste is not included in the scope of the Phase II RI. However, ERM will be responsible for characterizing, labeling, preparing manifests, and recommending applicable and appropriate disposal or treatment methods for any hazardous/dangerous wastes generated during the Phase II RI. These actions will be completed within 90 days of demobilization. The Seattle ANGS is ultimately responsible for disposal of IDW.

SECTION 10.0

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a summary of selected Federal and State ARARs that may be relevant to RI/FS activities at the Seattle ANGS, and a summary of the process used to establish PSGs for the project.

10.1 Federal Requirements

10.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

Section 121 (d) of CERCLA, as amended by SARA, addresses the management of Federal facilities. The IRP has been designed to mirror site investigation requirements under CERCLA (i.e., PA, SI, RI, FS, RD, and RA).

10.1.2 Resource Conservation and Recovery Act

RCRA regulations governing hazardous waste management provide both action- and chemical-specific ARARs that may apply to IRP activities at the Station.

10.1.2.1 Waste Identification

Waste materials generated at the site (e.g., drill cuttings, purge water, decontamination water) are regulated as hazardous waste if they meet the Federal definition provided in 40 Code of Federal Regulations (CFR) 261.

10.1.2.2 Waste Generation and Transport

RI activities or remedial alternatives involving the generation or transport of hazardous waste trigger RCRA hazardous waste generator requirements provided in 40 CFR 262. When hazardous waste is shipped

off site in regulated amounts, the manifesting and transport procedures in 40 CFR 263 must be followed.

10.1.2.3 Land Disposal Restrictions

RCRA regulations in 40 CFR 268 set forth Land Disposal Restrictions (also known as Land Ban Requirements) for RCRA wastes. These restrictions were required by the Hazardous and Solid Waste Amendments of 1984 to RCRA to prohibit the continued land disposal of hazardous wastes beyond specified dates. However, wastes treated in accordance with chemical-specific treatment standards provided in 40 CFR 268 Subpart D may be land-disposed as provided therein. The Land Disposal Restrictions potentially affect the storage and disposal of hazardous wastes generated during RI or subsequent remedial activities and may be considered both action- and chemical-specific ARARs.

10.1.2.4 Treatment, Storage, and Disposal Facilities

If remedial alternatives for the site involve the construction or off-site use of RCRA treatment, storage, or disposal (TSD) facilities, regulations provided in 40 CFR 264 become action-specific ARARs. Various subsections of 40 CFR 264 govern standards and procedures for the operation of hazardous waste TSD facilities. For example, a common disposal practice is to create a waste pile of contaminated soil as part of the remediation process. 40 CFR 264 Subpart L promulgates Federal RCRA standards for waste piles, including their design, operating requirements, monitoring and inspection, closure, and post-closure care. Other subparts control tank systems, surface impoundments, land treatment units, landfills, incinerators, and miscellaneous TSD units.

10.1.3 Safe Drinking Water Act

Federal regulations pursuant to the Safe Drinking Water Act (SDWA) govern the quality, usage, and discharge of groundwater as applied to drinking water quality. MCLs specified in 40 CFR 141.11-16 and 141.60-63 are legally enforceable Federal drinking water standards established by the USEPA. Maximum contaminant level goals (MCLGs) specified in 40 CFR 141.50-52 are non-enforceable, health-based goals for drinking water. MCLGs are set at levels at which no adverse health effects may arise. MCLs are set as close as practical to MCLGs. For non-carcinogens, MCLs are nearly always set at the MCLG. The USEPA believes that MCLs are protective of public health; however, it does recognize that specific

circumstances may require more stringent standards (i.e., MCLGs) for the protection of public health and the environment.

10.1.4 Clean Water Act

The Federal Clean Water Act and pursuant regulations provide potential location-, chemical-, and action-specific ARARs for IRP activities at the Seattle ANGS.

10.1.4.1 Ambient Water Quality Criteria

The USEPA has promulgated Ambient Water Quality Criteria (AWQC) for surface and groundwater through 40 CFR 131. Aligned with the Federal Clean Water Act criteria, the standard governing AWQC presents scientific data and guidance on the environmental effects of pollutants, rather than only establishing regulatory requirements. As a result, decision-makers evaluating remedial alternatives may compare their water quality data to Federal data and guidance. Candidate RAs involving contaminated surface water or groundwater must be evaluated within the context of follow-on water usage and the circumstances of the actual or potential release before implementation. As a general statement, AWQC are applied when evaluating cleanup levels for groundwater.

10.1.4.2 National Pollutant Discharge Elimination System

National Pollutant Discharge Elimination System (NPDES) regulations govern discharges to surface water and control surface water runoff from storm water discharge systems. Promulgation of Clean Water Act Section 402 and formal ARARs are established for NPDES through 40 CFR 122 and 40 CFR 125, and provide action- and chemical-specific ARARs.

10.1.5 Occupational Safety and Health Act

RI/FS field activities are governed by Occupational Safety and Health Act (OSHA) standards under 29 CFR 1910. Site workers must meet the requirements of the site health and safety plan, possess and use personal protective equipment in accordance with the health and safety plan, and take all precautions to eliminate exposure to unsafe or unhealthy situations. Other applicable OSHA ARARs include health and safety for Federal service contracts (29 CFR 1926) and record keeping and reporting under 29 CFR 1904.

10.1.6 Hazardous Materials Transportation Act

If material containing hazardous wastes is to be transported off site, U.S. Department of Transportation hazardous material transportation requirements in 49 CFR 171-179, pursuant to the Federal Hazardous Materials Transportation Act, may be action-specific ARARs for RI/FS activities. These requirements are supplemental to RCRA transporter requirements in 40 CFR 263.

10.1.7 Clean Air Act

The Federal Clean Air Act may provide action- and chemical-specific ARARs for IRP activities, including subsequent field investigations and RAs such as soil excavation or incineration. All remediation activities must comply with National Primary and Secondary Ambient Air Quality Standards found in 40 CFR 50. Rules governing particulate matter less than 10 microns in size (PM₁₀) are contained in 40 CFR 50, and are important due to the potential detrimental effects of such particles on the lungs. Field activities involving air emissions must ensure compliance with the PM₁₀ standard.

10.1.8 Federal Guidance to be Considered

In addition to Federal and State requirements that may be applicable or relevant and appropriate to IRP activities, Federal non-regulatory criteria must be considered. Chemical-specific Federal non-regulatory criteria, used to help characterize risks and to set cleanup goals, include the following:

- USEPA Risk Reference Doses;
- USEPA Health Advisories;
- USEPA Carcinogen Assessment Group Potency Factors;
- USEPA Acceptable Intake Values, Chronic and Subchronic; and
- USEPA guidance manual on water-related fate of 129 priority pollutants.

10.2 State Requirements

10.2.1 Model Toxics Control Act

The State of Washington has a toxic waste cleanup law entitled MTCA. MTCA is the State equivalent of CERCLA. MTCA outlines cleanup requirements to ensure the protection of human health and the environment while allowing flexibility in site-specific application of these requirements. MTCA defines a two-step approach for establishing cleanup requirements for individual sites. The first step is establishing cleanup standards and the second step is selecting cleanup actions that would best achieve the cleanup standards. The following summary of options for selecting cleanup levels is derived from WDOE (1996).

MTCA provides three options for establishing site-specific cleanup levels. Each of these options uses human health risk as the main determinant in setting cleanup levels.

10.2.1.1 Model Toxics Control Act Method A

MTCA Method A defines cleanup levels for 25 common contaminants (the Method A Tables). This method is designed to be used at sites that are relatively small or straightforward or include only a few contaminants. Typically, all of the contaminants found at such sites are listed on the Method A Tables.

10.2.1.2 Model Toxics Control Act Method B

MTCA Method B cleanup levels are developed using a site risk assessment that focuses on site characteristics, such as how the contaminants interact, what the combined health effects of the contaminants may be, and how the contaminants' movement on site and off site could threaten human health and the environment. This method is the most common one used for setting cleanup levels when sites are contaminated with substances not listed under Method A and environmental factors make site cleanup difficult. Natural background concentrations of a contaminant can be used when establishing cleanup levels.

The lifetime excess risk level for individual contaminants identified as carcinogens cannot exceed 1×10^{-6} . If more than one type of contaminant

is present, the total excess risk cannot exceed 1×10^{-5} . Concentrations of non-carcinogens cannot exceed a combined hazard index of 1 (the hazard index is the sum of the hazard quotients for individual hazardous substances).

10.2.1.3 Model Toxics Control Act Method C

MTCA Method C is similar to Method B. The main difference is that the lifetime excess cancer risk for carcinogenic contaminants is set at 1×10^{-5} for both individual contaminants and the total risk caused by all substances on a site. This method is used when cleanup levels established under Method A or B are technically impossible to achieve; are lower than area background concentrations; or may result in more harm to the environment than benefits. Use of this method requires proof to WDOE that the Method C cleanup levels will protect human health and the environment.

10.2.2 Hazardous Waste Management Act

The Washington Hazardous Waste Management Act (70.105 Revised Code of Washington) is the State equivalent of RCRA. The regulations that implement the Hazardous Waste Management Act are known as the Dangerous Waste Regulations, Chapter 173-303 WAC. Regulations governing dangerous waste management in the State of Washington provide both action- and chemical-specific ARARs that may apply to IRP activities at the Station.

10.2.2.1 Waste Identification

Waste materials generated at the site (e.g., drill cuttings, purge water, decontamination water) are regulated as dangerous waste if they meet the State definition provided in WAC 173-303.

10.2.2.2 Waste Generation and Transport

RI activities or remedial alternatives involving the generation or transport of dangerous waste trigger dangerous waste generator requirements provided in WAC 173-303. When dangerous waste is shipped off site in regulated amounts, the applicable manifesting and transport procedures must be followed.

10.3 Project Screening Goals (PSGs)

Numeric PSGs were developed during the Phase I RI for constituents that were detected in soil and groundwater samples. The PSGs were derived from ARARs, and are used to evaluate compliance of detected constituent concentrations with applicable regulatory criteria. The PSGs were also used to screen detected constituents for inclusion in the baseline risk assessment conducted as part of the Phase I RI.

Soil PSGs were derived according to the following criteria:

- 1) The MTCA Method A Table Value (residential soil cleanup level; WAC 173-340-740[2]) was used as the initial PSG.
- 2) If there was no MTCA Method A Table Value available, the MTCA Method B Formula Value (WAC 173-340-740[3]; WDOE, 1994a) was used as the initial PSG (cancer or non-cancer value, whichever was more stringent).
- 3) The regional natural background concentration was used if there was no MTCA Method A or Method B value available, or if the MTCA Method A (or Method B) value was less than the natural background concentration.
- 4) If there was no MTCA Method A, MTCA Method B, or natural background concentration value available, the site-specific background concentration (95 percent upper confidence limit [UCL] mean concentration; Table 3-3) was used.

Groundwater PSGs were derived according to the following criteria:

- 1) The MTCA Method A Table Value (groundwater cleanup level; WAC 173-340-720[2]) or the Federal Safe Drinking Water Act Primary MCL or Secondary Maximum Contaminant Level (SMCL; 40 CFR 141.11-16, 141.60-63, and 143.3) was used, whichever was more stringent.
- 2) If there was no MTCA Method A Table Value or MCL/SMCL available, the MTCA Method B Formula Value (WAC 173-340-720[3]; WDOE, 1994a) was used (cancer or non-cancer value, whichever was more stringent).

- 3) If there was no MTCA Method A, MCL/SMCL, or MTCA Method B value available, the site-specific background concentration (95 percent UCL mean concentration; Table 3-4) was used (data on regional natural background concentrations in groundwater were not available).

The PSGs developed for constituents detected in soil and groundwater at the Seattle ANGS and the numeric ARARs from which they were derived are summarized on Tables 10-1 and 10-2.

TABLE 10-1

*Numeric ARARs and Project Screening Goals for Constituents Detected in Soil
143rd CCSQ, Seattle ANG, Seattle, Washington*

Constituent	MTCA Method A Table Value (Residential Soil)	MTCA Method A Table Value (Industrial Soil)	MTCA Method B Cancer Formula Value	MTCA Method B Non-Cancer Formula Value	Regional Natural Background Concentration	Site-Specific Background Concentration*	Project Screening Goal
Organic Compounds: (mg/kg)							
Bis(2-ethylhexyl)phthalate	--	--	71.4	1,600	--	ND	71.4
TPH-Gasoline	100	100	--	--	--	ND	100
TPH-Diesel	200	200	--	--	--	ND	200
TPH-Heavy oil	200	200	--	--	--	ND	200
Trichloroethene	0.5	0.5	90.9	--	--	ND	0.5
Radionuclides: (pCi/g)							
Gross Alpha	--	--	--	--	--	9.96	9.96
Gross Beta	--	--	--	--	--	16.1	16.1
Radium-226	--	--	--	--	--	0.77	0.77
Radium-228	--	--	--	--	--	0.93	0.93
Metals: (mg/kg)							
Arsenic	20	200	1.43	60	7.3	5.59	20
Cadmium	2	10	0.164	80	0.77	ND	2
Chromium	100	500	--	--	48.15	14.2	100
Copper	--	--	--	2,960	36.36	15.8	2,960
Lead	250	1,000	--	--	16.83	18.2	250
Nickel	--	--	--	1,600	38.19	10.5	1,600
Selenium	--	--	--	400	--	1.66	400
Zinc	--	--	--	24,000	85.06	30.1	24,000

mg/kg = Milligrams per kilogram

pCi/g = PicoCuries per gram

MTCA = Model Toxics Control Act

-- = Standard not established/value not available

* Site-specific background concentration corresponds to the 95% upper confidence limit (UCL) mean concentration in RI background samples.

ND = Constituent not detected in RI background samples.

Sources: MTCA Method A Table Values: WAC 173-340-740 (Table 2) and WAC 173-340-745 (Table 3), MTCA Method A Cleanup Levels for Soil.

MTCA Method B Formula Values: MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, 1995.

Regional Natural Background Concentrations: Natural Background Soil Metals Concentrations in Washington State, October 1994
(Washington State Department of Ecology Publication 94-115), Table 17, Puget Sound values.

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TABLE 10-2
Numeric ARARs and Project Screening Goals for Constituents Detected in Groundwater
143rd CCSQ, Seattle ANG, Seattle, Washington

Constituent	MTCA Method A Table Value	Federal Primary MCL	Federal Secondary MCL	MTCA Method B Cancer Formula Value	MTCA Method B Non-Cancer Formula Value	Site-Specific Background Concentration*	Project Screening Goal
Organic Compounds: (µg/l)							
Acetone	—	—	—	—	800	ND	800
Benzene	5	5	—	1.51	—	ND	5
1,1-Dichloroethane	—	—	—	—	800	0.513	800
1,2-Dichloroethane	5	5	—	0.481	—	ND	5
cis-1, 2-Dichloroethene	—	70	—	—	80	ND	70
Ethylbenzene	30	700	—	—	800	ND	30
Tetrachloroethene	5	5	—	0.858	80	7.33	5
Toluene	40	1,000	—	—	1,600	1.04	40
1,1,1-Trichloroethane	200	200	—	—	7,200	2.63	200
Trichloroethene	5	5	—	3.98	—	ND	5
1,3,5-Trimethylbenzene	—	—	—	—	—	0.507	0.507
Xylenes	20	10,000	—	—	16,000	ND	20
Radionuclides:							
Gross Alpha	15 pCi/l	15 pCi/l	—	—	—	2.09 pCi/l	15 pCi/l
Gross Beta	4 mrem/yr	4 mrem/yr	—	—	—	11.3 pCi/l	11.3 pCi/l (1)
Radium-226	3 pCi/l	—	—	—	—	0.236 pCi/l	3 pCi/l
Radium-226 and 228	5 pCi/l	5 pCi/l	—	—	—	0.494 pCi/l	5 pCi/l
Radium-228	2 pCi/l (2)	—	—	—	—	0.258 pCi/l	2 pCi/l
Metals: (µg/l)							
Arsenic	5	50	—	0.05	4.8	ND	5
Copper	—	—	1,000	—	592	8.06	1,000
Nickel	—	100	—	—	320	9.66	100
Zinc	—	—	5,000	—	4,800	51	5,000

µg/l = Micrograms per liter

pCi/l = PicoCuries per liter

mrem/yr = Millirem per year

— = Standard not established

MTCA = Model Toxics Control Act

MCL = Maximum Contaminant Level (Enforceable Level) for drinking water

ND = Constituent not detected in RI background samples.

(1) = The site-specific background concentration for gross beta radiation was chosen as the project screening goal rather than the MTCA Method A Table Value because laboratory results were reported as concentrations, not dosages. The MTCA Method A Table Value is given as a dosage, and is thus not as easily compared with sample results.

(2) = MTCA Method A Tables for groundwater report a combined Radium-226 and Radium-228 cleanup level of 5 pCi/l. The cleanup level for Radium-226 alone is 3 pCi/l. Therefore, the cleanup level for Radium-228 alone is approximated at 2 pCi/l.

*Site-specific background concentration corresponds to the 95% upper confidence limit (UCL) mean concentration in RI background samples.

Sources: MTCA Method A Table Values: WAC 173-340-720, MTCA Method A Cleanup Levels for Groundwater.

MTCA Method B Formula Values: MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, 1995.

Primary and Secondary MCLs: 40 Code of Federal Regulations 141.11-16, 141.60-63, and 143.3.

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SECTION 11.0

CONTAMINANT FATE AND TRANSPORT

Data collected during the Phase II RI regarding site physical characteristics and contaminant source characteristics will be combined in the analysis of contaminant fate and transport.

The following items will be addressed as part of the fate and transport evaluation in the Phase II RI/FS report:

- Contaminant mobility and potential routes of migration;
- Contaminant persistence;
- Location and characteristics of potential receptors; and
- Potential exposure pathways.

Studies published in scientific literature will be used to evaluate contaminant persistence and potential for migration. Site-specific soil and groundwater data will be used where possible to evaluate the applicability of the results of published studies to environmental conditions at the Seattle ANGS.

SECTION 12.0

BASELINE RISK ASSESSMENT

The State of Washington has developed human health risk assessment procedures to be used in establishing site-specific cleanup levels for contaminants (WAC 173-340-708). This section provides a summary of the risk assessment procedures that will form the basis of the RI baseline risk assessment.

12.1 Purpose of the Baseline Risk Assessment

A baseline risk assessment provides an evaluation of the potential threat to human health and the environment posed by a site in the absence of any RA. The assessment provides the basis for determining whether or not RAs are necessary and the justification for performing RAs.

A screening-level baseline risk assessment will be conducted for the Seattle ANGS during the Phase II RI. The scope of the screening-level baseline risk assessment is detailed in the subsections that follow.

12.2 Identification of Contaminants of Concern

COCs will be identified at each IRP site in order to focus subsequent efforts in the risk assessment process. COCs may be selected for any of the following reasons: non-compliance with ARARs; intrinsic toxicological properties; presence at concentrations exceeding area background concentrations; and/or the potential of the chemical to migrate into critical exposure pathways (e.g., drinking water). In the event that multiple contaminants are found to be present at the Station, a subset of contaminants or an indicator contaminant may be selected as the COC(s) for the purposes of the risk assessment. The subset would include those contaminants that pose the greatest potential risk based on concentration and/or quantity relative to ARARs and area background, toxicity, detection frequency, mobility, and persistence.

12.3 Toxicity Assessment

The toxicity assessment includes collection of available data regarding the potential for COCs to cause adverse effects in exposed individuals. This information is used in conjunction with total exposure estimates to determine the relationship between the extent of exposure to a COC and the increased likelihood and/or severity of adverse effects in the exposed individual. The toxicity assessment will rely on existing toxicity information published in the scientific literature and will not include the development of new data on toxicity or dose-response relationships. The WDOE publishes an annual update of toxicological data to be used in calculating cleanup levels under MTCA. The most recent annual update from WDOE and the USEPA Integrated Risk Information System database will be used in performing the toxicity assessment.

12.4 Exposure Assessment and Risk Characterization

The final component of the risk assessment process is an exposure assessment and characterization of the potential risks of adverse health or environmental effects from the COCs identified at the site. This component of the screening-level baseline risk assessment will be addressed by:

- Identifying potential receptors that may be at risk;
- Identifying exposure pathways; i.e., determining how COCs may migrate from a source to an existing or potential point of human contact;
- Quantifying potential exposure; i.e., estimating magnitude, frequency, and duration of the exposure; and
- Quantifying potential health risks related to the exposure.

MTCA specifies that site-specific cleanup levels shall be based on estimates of current and future resource uses and reasonable maximum exposures expected to occur under both current and potential site use conditions. Because individuals may be exposed to contaminants through more than one exposure pathway, the reasonable maximum exposure will take into account the total exposure through all of the potential exposure pathways.

If the results of the risk characterization indicate that the Station poses little or no threat to human health or the environment, the FS may be scaled back appropriately or eliminated altogether. In this case, the results of the Phase I and II RI analytical testing and the Phase II screening-level baseline risk assessment would serve as the primary means of documenting a No Further Action recommendation.

SECTION 13.0

FEASIBILITY STUDY

This section describes the basic scope of the FS planned for the Seattle ANGS. The development and site-specific content of the FS will be based on the findings of the RI. The FS scope outlined below follows guidance contained in the USEPA document *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988).

13.1 Purpose and Organization

The purpose of the FS is to develop and screen remedial alternatives for addressing contaminated media identified during the RI. A focused FS approach may be applied if site conditions are favorable. USEPA guidance entitled *Presumptive Remedies: Policy and Procedures* (USEPA, 1993) outlines the elements of a focused FS.

13.2 Development of Remedial Alternatives

The primary objective of this phase of the FS is to develop an appropriate range of remedial alternatives that will be screened for later evaluation during the detailed and comparative analysis phase of the FS. Potentially applicable treatment technologies and process options for site remediation will be identified for both soil and groundwater. Potential remediation technologies will be gathered from USEPA documents, various research documents, and private industry documents. Also, experts in various fields of remediation technology from both government and the private sector will be consulted, as necessary, concerning the appropriateness of a technology for the site.

13.3 Preliminary Screening of Alternatives

The screening criteria that will be used to assess the remedial alternatives are effectiveness, implementability, and cost. The alternatives will be screened in a two-step process. The first step will assess the applicability of a particular remedial approach or remediation technology to site conditions. Each alternative will be evaluated based on the properties of contaminants present at the site and the site geologic and hydrogeologic conditions. Those remedial alternatives determined not to be applicable will be eliminated from further consideration. The second step of the screening process will compare the potentially applicable remedial alternatives in terms of their relative effectiveness, implementability, capital costs, and operation and maintenance costs. Each of the potentially applicable remedial alternatives will be ranked relative to the others using these criteria.

The criterion of effectiveness addresses the technical ability of the remedial approach or remediation technology to achieve the remedial action objectives. The criterion of implementability addresses the ability of the remedial alternative to be implemented based on factors such as institutional constraints, site conditions, types of contaminants to be treated, available process options, and the degree of difficulty in designing a viable treatment process for the site. Capital and operation and maintenance costs for each remedial alternative will be classified as low, moderate, or high.

13.4 Detailed Analysis of Alternatives

A detailed analysis of remedial alternatives will follow the development and screening of alternatives and will precede the actual selection of a remedy. The National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR 300.430 (iii) sets forth nine criteria to be used for detailed analysis of the alternatives retained after the screening portion of the FS. The nine criteria that will be used for the detailed analysis are as follows:

- Overall protection of human health and the environment;
- Compliance with ARARs (i.e., standards, criteria, or limits promulgated under federal or state law);

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

13.5 Comparative Analysis of Alternatives

Once the remedial alternatives have been described and individually assessed against the evaluation criteria, a comparative analysis will be conducted to assess the relative performance of each alternative in relation to each specific criterion. This is in contrast to the preceding analysis in which each alternative is analyzed independently without consideration of the other alternatives. The purpose of the comparative analysis is to determine the advantages and disadvantages of each alternative relative to one another so that the key tradeoffs that must be balanced are identified. Overall protection of human health and the environment and compliance with ARARs will generally serve as threshold determinations in that they must be met by any alternative in order for it to be eligible for selection as the final remedy.

13.6 Report and Recommendations

An FS report will be prepared to document the development and analysis of remedial alternatives. It will include background information about the site based on the RI report, the remedial action objectives for soil and/or groundwater, the estimated volume or area of soil and/or groundwater to which remedial alternatives will be applied, and descriptions of the remedial alternative development, screening, and analysis procedures and results. The FS report will also present the preferred cleanup remedy and provide recommendations for implementing the remedy.

SECTION 14.0

REMEDIAL INVESTIGATION REPORT**14.1 Purpose**

The purpose of the RI report is to present a summary and interpretation of the investigative work performed during the RI.

14.2 Format

The RI portion of the Phase II RI/FS report will be prepared in accordance with ANG/CEVR guidelines. The outline and format of the report will be consistent with the outline and format of the Phase I RI report. The outline of the Phase I RI report (ERM, 1998) is presented below.

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FEASIBILITY STUDY REPORT**15.1 Purpose**

The purpose of the FS report is to describe the development, screening, and detailed analysis of remedial alternatives for contaminated media identified at the Seattle ANG.

15.2 Format

The FS portion of the Phase II RI/FS report will be prepared in accordance with the suggested ANG/CEVR report outline. A sample outline for the FS report is presented below.

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PROJECT SCHEDULE AND DELIVERABLES

Figure 16-1 presents the current project timeline schedule for the Seattle ANGS Phase II RI/FS. Field work is expected to start one week after submittal of the Final Phase II RI/FS Work Plan. The project will be completed upon submittal of the Final Phase II RI/FS report. Due to the interdependency of many of the project tasks, this schedule may be adjusted in the future based on the actual duration and completion dates of individual tasks.

ID	Task Name	Duration	Start	Finish
1	Prepare Phase 2 RUFFS Work Plan	130d	Thu 1/29/98	Mon 8/3/98
2	Task 2A - Prepare Draft Phase 2 RUFFS Work Plan	20d	Thu 1/29/98	Thu 2/26/98
3	ANG Review - Draft Phase 2 RUFFS Work Plan	20d	Mon 3/2/98	Fri 3/27/98
4	Task 1A - Draft Phase 2 RUFFS Workplan Review Meeting	3d	Mon 3/30/98	Wed 4/1/98
5	Task 2B - Prepare Draft Final Phase 2 RUFFS Work Plan	15d	Mon 4/27/98	Fri 5/15/98
6	ANG/Regulatory Review - Draft Final Phase 2 RUFFS Work Plan	20d	Mon 5/18/98	Mon 6/15/98
7	Task 1B - Reg. Review Mtg. - Draft Final Phase 2 RUFFS Work Plan	4d	Mon 6/15/98	Thu 6/18/98
8	Task 2C - Prepare Final Phase 2 RUFFS Work Plan	15d	Tue 7/14/98	Mon 8/3/98
9	Field Work	210d	Mon 8/10/98	Mon 8/7/99
10	Task 3 - Field Work	29d	Mon 8/10/98	Fri 9/18/98
11	Task 3 - 1st Quarterly Groundwater Sampling Event	5d	Mon 9/21/98	Fri 9/25/98
12	Task 3 - 2nd Quarterly Groundwater Sampling Event	5d	Mon 12/14/98	Fri 12/18/98
13	Task 3 - 3rd Quarterly Groundwater Sampling Event	5d	Mon 3/9/99	Fri 3/12/99
14	Task 3 - 4th Quarterly Groundwater Sampling Event	5d	Tue 8/1/99	Mon 8/7/99
15	Prepare Phase 2 RUFFS Report	182d	Mon 8/21/98	Tue 8/22/99
16	Task 4A - Prepare Draft Phase 2 RUFFS Report	50d	Mon 9/21/98	Mon 11/30/98
17	ANG Review - Draft Phase 2 RUFFS Report	22d	Wed 12/2/98	Mon 1/4/99
18	Task 1C - Draft Phase 2 RUFFS Report Review Meeting	3d	Tue 1/5/99	Thu 1/7/99
19	Task 4B - Prepare Draft Final Phase 2 RUFFS Report	20d	Mon 2/9/99	Mon 3/8/99
20	ANG/Regulatory Review - Draft Final Phase 2 RUFFS Report	20d	Tue 3/9/99	Mon 4/5/99
21	Task 1D - Reg. Review Mtg. - Draft Final Phase 2 RUFFS Report	4d	Tue 4/6/99	Fri 4/9/99
22	Task 4C - Prepare Final Phase 2 RUFFS Report	45d	Tue 4/20/99	Tue 8/22/99

Project: Seattle ANGSI RIFS - Phase 2
Location: Seattle, Washington
Environmental Resources Management

Summary Task

Subtask

SEARCHED

FIGURE 16-1
Phase II RI/FS Project Schedule
143rd CCSQ, Seattle ANG, Seattle, Washington

SECTION 17.0

REFERENCES

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WDOE, 1994b, *Natural Background Soil Metals Concentrations in Washington State*, Publication No. 94-115, October 1994.

WDOE, 1995, *Guidance on Sampling and Data Analysis Methods*, Publication No. 94-49, January 1995.

WDOE, 1996, *The Model Toxics Control Act Cleanup Regulation, Chapter 173-340 WAC*, Publication No. 94-06, Amended January 1996.

APPENDIX A

SITEWIDE SAFETY AND HEALTH PLAN

EMERGENCY REFERENCES

Key Telephone Numbers

AMBULANCE	911
POLICE	911
FIRE	911
HOSPITAL	911
NATIONAL RESPONSE CENTER	1-800-424-8802
POISON CONTROL CENTER	1-800-682-9211
TOXLINE	1-301-496-1131
CHEMTREC	1-800-424-9300
ERM, WALNUT CREEK OFFICE	1-510-946-0455
ERM, BELLEVUE OFFICE	1-425-462-8591
BASE SAFETY MANAGER	SMS Dan Brewer 1-206-764-5608

Nearest Hospital

Harborview Medical Center 325 Ninth Avenue Seattle, Washington	1-206-223-3074
--	----------------

Directions to Hospital (See Figure A-1)

Exit the Seattle ANGS through the main entrance. Turn right (north) onto Ellis Avenue. In one block, turn left (west) onto Warsaw Street. In one block, turn north onto Corson Avenue, and follow signed lanes to

Interstate 5. Enter Interstate 5 Northbound. Exit Interstate 5 at the James Street Exit (Exit 164) and exit the collector/distributor on the James Street off-ramp. Turn right (east) on James Street, follow 2 blocks to 9th Avenue. Turn right on to 9th Avenue, Harborview Hospital is on the right.

ERM Representatives

PROJECT MANAGER	Robert Leet
SITE MANAGER	Don Wyll
SITE HEALTH AND SAFETY OFFICER	Don Wyll
DIRECTOR, HEALTH AND SAFETY	Steven Meyers, C.S.P., C.I.H.

FINAL

Mag 13.00
Fri Mar 15 10:23:24 1996

Scale 1:62,500 (at center)

1 Miles

2 KM

LEGEND

- State Route
- Geo Feature
- Major City
- ◇ Town, Small City
- ✚ Hospital
- ▲ Park
- ▭ Interstate, Turnpike
- Population Center
- Street, Road
- Hwy Ramp
- Major Street/Road
- Street, Road
- Interstate Highway
- State Route
- +++ Railroad
- River
- ▭ Land Mass
- ▭ Open Water
- Route to Hospital

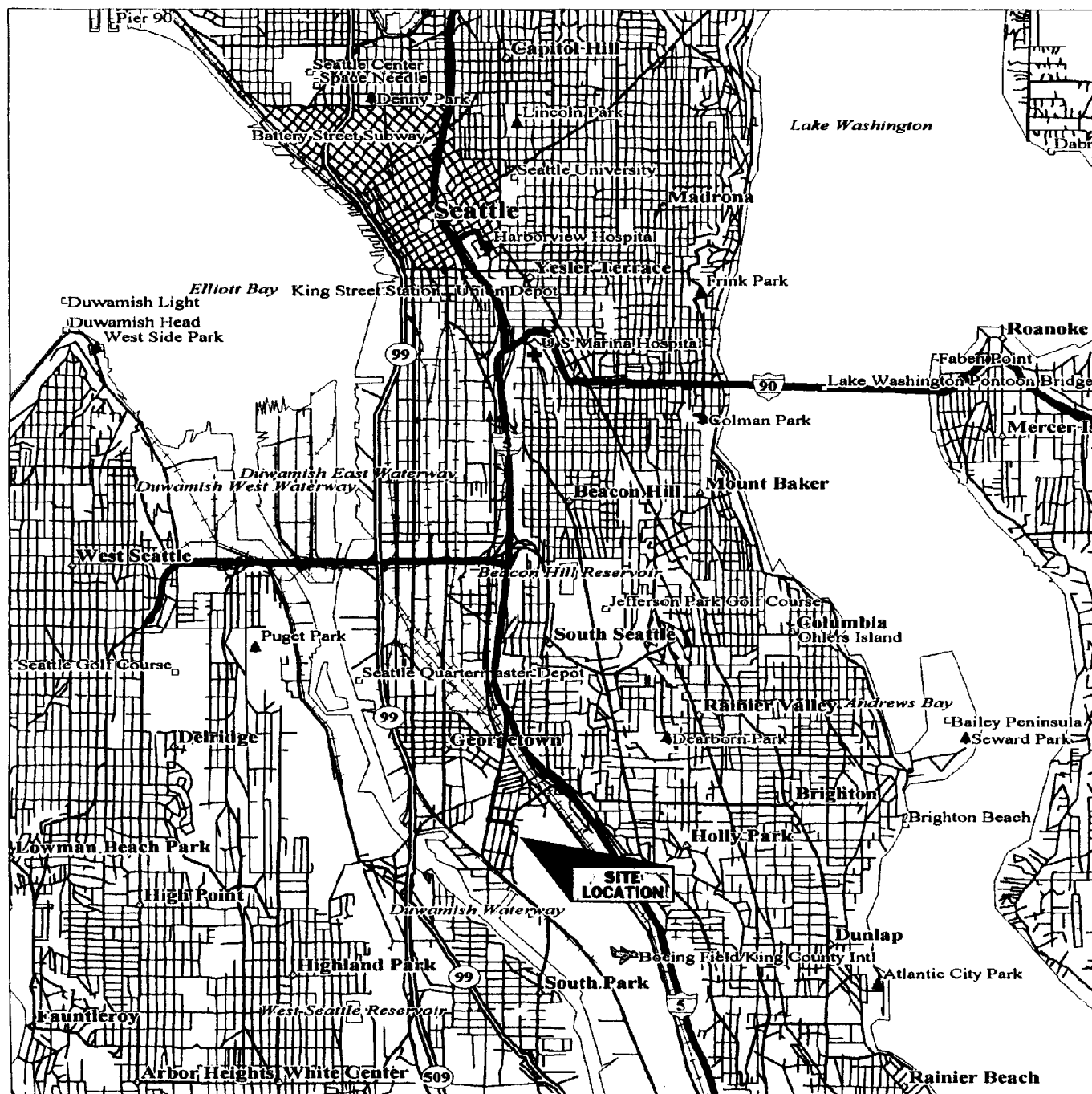


FIGURE A-1
Map to Hospital

A-3

KCSlip4 40996

SEA407526

EMERGENCY RESPONSE PLAN SUMMARY

In the event of a health or safety emergency at the site, appropriate emergency measures will immediately be taken to assist those who have been injured or exposed and to protect others from hazards. The Site Safety and Health Officer will be immediately notified and will respond according to the seriousness of the injury. Personnel trained in first aid will be present during site activities to provide appropriate treatment of injuries or illnesses incurred during field operations. The ERM Project Manager and Site Manager shall be immediately informed of any serious injuries.

Additional emergency response and accident investigation procedures are detailed in Section 7.0 of this Safety and Health Plan.

General Evacuation Plan

In case of fire, explosion, or toxic vapor release, a site evacuation may be ordered by the Site Safety and Health Officer. The following procedure shall be followed in the event of an evacuation:

- Announce the evacuation via radio/horn and notify ANG personnel and others in site buildings, then immediately call 911;
- Evaluate the immediate situation and downwind direction. All personnel will evacuate in the upwind direction;
- All personnel will assemble in an upwind area when the situation permits, and a head count will be taken by the Site Safety and Health Officer; and
- Await the arrival of local qualified emergency response personnel.

First Aid

Qualified personnel on site shall give first aid and stabilize any worker needing assistance. Professional medical assistance shall be obtained at

the earliest possible opportunity. If assistance beyond first aid is required, call 911 and request emergency medical assistance.

A first-aid kit and emergency 16-ounce eyewash station shall be maintained readily accessible to all workers. The 16-ounce eyewash station should be supplemented by a nearby 15-minute eyewash station.

Emergency first aid for organic hazardous substances is outlined in Section 7.4 of this Safety and Health Plan.

Spills or Hazardous Material Releases

Spills or hazardous material releases that pose a potential threat to human health or the environment shall be reported to the appropriate authorities by the Site Safety and Health Officer. Small spills that do not pose a threat shall be reported to the Site Safety and Health Officer and will be addressed per the chemical manufactures' recommended procedures.

In the unlikely event of a significant release of hazardous material during field work, the proper state and local authorities will be immediately notified. Appropriate actions will be taken to protect the public and control the continued release or migration of the hazardous material.

Emergency Operation Shutdown Procedures

In the event a hazardous situation develops on site, the Site Safety and Health Officer may temporarily suspend operations until the situation is corrected or controlled. The Site Safety and Health Officer will have the authority to restart operations when the situation as been corrected and safe working conditions have been restored.

DISCLAIMERS AND LIMITATIONS ON USE

Environmental Resources Management ("ERM") developed the following Sitewide Safety and Health Plan (the "SSHP") for use by ERM personnel and by ERM subcontractors (individually, an "ERM Contractor" and collectively, "ERM Contractors") in connection with soil and groundwater investigation, monitoring, and remediation activities (the "Project") being performed by ERM for the Air National Guard Readiness Center (the "Client") at the Seattle Air National Guard Station in Seattle, Washington (the "Site"). ERM personnel must adhere to the practices and procedures specified in the SSHP.

Each ERM Contractor must review the SSHP and agree to accept and abide by the SSHP, subject to any modifications to the SSHP (to address the ERM Contractor's more stringent practices and procedures) agreed upon in writing by ERM and the ERM Contractor. The ERM Contractor shall indicate such acceptance by executing a copy of this notice of disclaimers and limitations on use as indicated below and returning it to ERM's project manager for the Project prior to commencing work at the Site. However, if any ERM Contractor commences work at the Site, the ERM Contractor shall be deemed to have accepted the SSHP and the terms hereof and the failure to execute and return to ERM a copy of this notice shall not be relevant to such interpretation.

If a contractor or a person other than the Client, ERM employees and ERM Contractors (individually, a "Third Party" and collectively, "Third Parties") receives a copy of the SSHP, such Third Party should not assume that the SSHP is appropriate for the activities being conducted by the Third Party. NO THIRD PARTY HAS THE RIGHT TO RELY ON THE SSHP. EACH THIRD PARTY SHOULD ABIDE BY ITS OWN SSHP IN ACCORDANCE WITH ITS OWN PROFESSIONAL JUDGMENT AND ESTABLISHED PRACTICES.

ERM shall not be responsible for the implementation of any Third Party's safety program(s), except to the extent otherwise expressly agreed upon by ERM and a Third Party in writing. The services performed by ERM for the Client and any right of the Client and/or an ERM Contractor to rely on the SSHP shall in no way inure to the benefit of any Third Party, *including, but not limited to*, employees, agents, or consultants and subcontractors of ERM Contractors, so as to give rise to any cause of action by such Third Party against ERM.

The SSHP generated by ERM in connection with the Project is for use on a specific site and in connection with a specific project. ERM makes no representation or warranty as to the suitability of the SSHP for reuse on another site or as to the suitability of the SSHP for reuse on another project or for modifications made by the Client or a Third Party to the SSHP.

ERM Contractors Only

Agreed and Accepted:

Contractor's Name: _____

By: _____

Title: _____

Date: _____

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SECTION 1.0

INTRODUCTION

This Sitewide Safety and Health Plan (SSHP) has been developed by Environmental Resources Management (ERM) to establish the safety and health procedures required to minimize potential hazards to personnel who will be involved in soil and groundwater investigation, monitoring, and remediation activities planned for the Seattle Air National Guard Station (Seattle ANG) in Seattle, Washington. The provisions of this SSHP directly apply to ERM personnel and contractors, if utilized, who will be potentially exposed to safety and/or health hazards related to the project. This SSHP does not directly apply to Air National Guard (ANG) personnel, although ERM will advise ANG personnel on the safety and health aspects of the work based upon the guidelines specified in this SSHP.

The procedures in this SSHP have been developed based upon current knowledge regarding the specific chemical and physical hazards that are known or anticipated for the operations to be conducted at the Station. This SSHP has been written to comply with the requirements of ERM safety and health policies. It is ERM's policy that activities covered by this SSHP must be conducted in complete compliance with this SSHP and with all applicable federal, state, and local safety and health regulations, including the federal Occupational Safety and Health Administration (OSHA) Construction Industry Standards in 29 Code of Federal Regulations (CFR) 1910.120. On-site personnel who cannot, or will not, comply with these requirements will be excluded from project activities. Prior to the commencement of field activities, all ERM and subcontractor personnel covered by this SSHP must review this document and return the sign-off form to the Site Manager.

1.1 Site Description and History

This section discusses the general history and physiography of the Seattle ANG in Seattle, Washington. Site location and land use are described, hazardous chemicals associated with site activities and known releases are identified, and general site characteristics are presented.

1.1.1 Location

The Seattle ANGS is located in the northwest corner of King County International Airport (also known as Boeing Field), in Seattle, Washington. The Seattle ANGS, which is the headquarters for the 143rd Combat Communications Squadron (CCSQ), is located at 6736 Ellis Avenue South and currently occupies 7.5 acres. Boeing Field is located approximately 3 miles south of the Seattle central business district. Land use in the vicinity of the Seattle ANGS is industrial, residential, and commercial.

1.1.2 Operations History

Seattle ANGS was built during World War II by the War Department and was used by the Army Air Force as the "Aircraft Factory School" during the war. In 1948, the property was transferred to King County as surplus property and was subsequently leased to the Washington ANG.

On 21 April 1948, the 143rd Aircraft Control and Warning Squadron was established. From May 1951 to February 1953, the 143rd was activated for recruitment purposes. During this period of time, the unit has two C-47 aircraft. In 1960, the name of the unit was formally changed to the 143rd communication Squadron Tributary Teams. In 1969 and 1988, the name of the unit was again changed, becoming the 143rd Mobile Communications Squadron and the 143rd CCSQ, respectively. The current mission of the 143rd CCSQ is to provide mobile communication equipment and support for airports and airfields.

In 1948, the Seattle ANGS consisted of 17 acres of land, including an aircraft parking ramp, leased from King County. At that time, the property contained 15 buildings (including a number of small shed structures), all of which were subsequently demolished. In 1951, a new property lease decreased the size of the ANGS from 17 acres to its present size of 7.5 acres, and buildings were constructed for headquarters, mess hall, warehouse, and vehicle service requirements.

In 1980, the National Guard Bureau and Congress funded \$2.3 million for the replacement of all buildings at the Seattle ANGS. The buildings were completed in 1984, with the exception of the Mobility Warehouse, which was completed in 1988. Seattle ANGS now consists of 7.5 acres and four buildings with a total area of 34,698 square feet. The Seattle ANGS property is leased from King County by the U.S. Air Force, who in turn

licenses the property to the Washington State Military Department for Air National Guard use.

The operations of the 143rd CCSQ include ground vehicle maintenance; electrical maintenance; and petroleum, oil, and lubricants (POL) distribution and management. Significant quantities of gasoline, diesel fuel, and engine oil are used on the Seattle ANGS, as are smaller amounts of industrial solvents, antifreeze, paints, and acids. Typical wastes include contaminated fuels, spent solvents, off-specification materials, and refrigeration oils.

1.2 Prior Investigations

1.2.1 Preliminary Assessment and Site Inspection

A Preliminary Assessment/Site Inspection (PA/SI) was completed by Operational Technologies Corporation (OpTech) between 1991 and 1995. OpTech completed a geophysical survey, soil gas survey, and three soil borings, and installed a total of 3 groundwater monitoring wells in the Burial Site Area of Concern (AOC) at the Seattle ANGS. The geophysical survey was completed using ground-penetrating radar (GPR) and magnetometer methods to detect possible buried waste materials or containers in the AOC.

Beryllium and total petroleum hydrocarbons (TPH) were detected at concentrations greater than Model Toxics Control Act (MTCA) cleanup levels in soil samples collected by OpTech from the soil borings at the Burial Site AOC. Beryllium was detected at a maximum concentration of 1.1 milligrams per kilogram (mg/kg). TPH was detected at a maximum concentration of 780 mg/kg. Gross alpha and gross beta analyses of soil samples indicated particle activities from 0 to 4 picoCuries per gram (pCi/g).

Arsenic, beryllium, chromium, and lead were detected at concentrations greater than MTCA cleanup levels in groundwater samples collected by OpTech from the monitoring wells at the Burial Site AOC. The maximum concentrations detected in the groundwater samples were as follows: arsenic - 28 micrograms per liter ($\mu\text{g/l}$), beryllium - 820 $\mu\text{g/l}$, chromium - 97 $\mu\text{g/l}$, and lead - 26 $\mu\text{g/l}$. Gross alpha and gross beta analyses of groundwater samples indicated particle activities from 15 to 77 picoCuries

per liter (pCi/l). The MTCA method A cleanup level for gross alpha activity is 15.0 pC/l.

1.2.2 Phase I Remedial Investigation

During the Phase I Remedial Investigation (RI), the results of the soil and groundwater chemical analyses were compared to project screening goals (PSGs) developed for the Station. Based on this comparison, potential contaminants of concern (COCs) were identified in soil and groundwater at the site. Potential COCs include those constituents detected in at least one Phase I RI sample at concentrations above PSGs. Detections of constituents attributable to area background concentrations or suspected laboratory contamination (i.e., radionuclides, metals, and semivolatile organic compounds) were excluded.

Potential COCs identified at the Seattle ANGS include:

Soil

- TPH as gasoline, diesel, and heavy oil
- Trichloroethylene (TCE)

Groundwater

- | | |
|--------------------------|-----------------------------|
| • Benzene | • 1,1,1-trichloroethane |
| • Toluene | • TCE |
| • Ethylbenzene | • Acetone |
| • Xylenes | • 1,3,5-trimethylbenzene |
| • cis-1,2-dichloroethene | • Tetrachloroethylene (PCE) |
| • 1,2-dichloroethane | |

The distribution of volatile organic compounds (VOCs) detected in groundwater at the Station does not display any clear pattern to suggest the possible source(s) of the VOCs. The Paint Storage Building (Building 203) may represent a source of the dissolved VOCs detected in "background" monitoring well BS-004PZ. However, the Phase I RI data were not sufficient to determine whether Building 203 or a different source may be present.

1.3 Investigation Work Plan

Forty soil gas sampling points, 20 Geoprobe™/ Hydropunch™ sample points, and five groundwater monitoring wells will be installed during Phase II RI field activities. Additionally, four quarterly rounds of groundwater samples will be collected from each new and existing groundwater monitoring well for laboratory analysis.

Details regarding the activities to be conducted during the Phase II RI are discussed in the investigation work plan entitled *Installation Restoration Program (IRP) Phase II Remedial Investigation/Feasibility Study Work Plan* (ERM, 1998).

SECTION 2.0

KEY PERSONNEL

The organization and responsibilities for implementing safe project activities, and more specifically the requirements contained in this SSHP, are discussed in this section.

The key personnel for this project are:

- | | |
|--|--------------------|
| • Project Manager | Robert Leet |
| • Site Manager | Don Wyll |
| • Site Safety and Health Officer | Don Wyll |
| • Director of Internal Safety and Health | Steven Meyers, CIH |

2.1 Project and Site Manager

The ERM Project Manager is, by designation, the individual who has the primary responsibility for ensuring the overall safety and health of this project. The Site Manager has the primary responsibility for ensuring the SSHP is implemented in the field. The Site Manager's specific responsibilities include:

- Ensuring that all site project personnel have received a copy of and have read this SSHP and have completed the SSHP signature sheet;
- Requiring the attendance of all site personnel to a daily tailgate briefing apprising them of the contents of this SSHP and the specific hazards present at the facility prior to performing work;
- Ensuring that sufficient personal protective equipment (PPE), as required by this SSHP, is available during the project;
- Obtaining all subcontractor documentation of employee participation in a medical monitoring and health and safety training program;

- Maintaining a high level of safety and health consciousness among employees at the facility; and
- Maintaining regular communications with the Site Safety and Health Officer (SHO), the Project Manager, and, if necessary to resolve safety and health conflicts, the Director of Internal Safety and Health (DISH).

2.2 Site Safety and Health Officer

The appointed SHO will be a member of the ERM project field team. The SHO responsibilities include enforcing the requirements of this SSHP once work begins. By design, the SHO has the authority to immediately correct all situations where noncompliance with this SSHP is noted and to immediately stop work in cases where an immediate danger is perceived. The SHO's specific responsibilities include:

- Procuring and distributing the PPE and air monitoring instrumentation needed for the project;
- Verifying that all PPE and safety and health equipment is in good working order;
- Setting up and maintaining the personnel decontamination facility;
- Controlling site entry of unauthorized personnel;
- Supervising and monitoring the safety performance of all personnel to ensure that required safety and health procedures are followed, and correcting any deficiencies;
- Conducting accident/incident investigations and preparing investigation reports; and
- Initiating emergency response procedures.

2.3 Director of Internal Safety and Health

ERM's DISH is the individual responsible for the preparation, interpretation, and modification of this SSHP. Modifications to this SSHP which may result in less stringent precautions cannot be undertaken by the Project Manager, Site Manager, or SHO without the approval of the DISH. Specific responsibilities of the DISH include:

- Advising the Project Manager, Site Manager, and SHO on matters relating to safety and health on this project;
- Recommending appropriate PPE and air monitoring instrumentation to protect personnel from potential hazards present on site;
- Performing field audits, when necessary, to monitor the effectiveness of the SSHP and to ensure compliance with it;
- Conducting or directing personal exposure monitoring where required and where deemed necessary to determine the adequacy of protective measures and PPE specified by this SSHP;
- Maintaining contact with the Project Manager to regularly evaluate project conditions and new information which might require modification to this SSHP;
- Working with the Site Manager to ensure that sufficient PPE is available at the site; and
- Conducting briefing meetings, when necessary, to apprise personnel of the contents of this SSHP and the project hazards.

2.4 Field Personnel

All field and subcontractor personnel are responsible for following the safety and health procedures specified in this SSHP and for performing their work in a safe and responsible manner. Specific requirements include:

- Obtaining a copy of this SSHP and reading it, in its entirety, prior to the start of field activities;
- Signing the Safety and Health Signature Sheet acknowledging receipt and understanding of this SSHP;
- Bringing forth any questions or concerns regarding the content of the SSHP to the SHO, Site Manager, Project Manager, or DISH prior to the start of work;
- Reporting accidents/incidents and the presence of potentially hazardous working situations to the SHO and Site Manager; and

- Complying with the requests of the appointed SHO.

SECTION 3.0

PARTICIPANT QUALIFICATIONS

3.1 Training Requirements

All ERM field personnel working on the Seattle ANGS RI and Feasibility Study (FS) activities will have completed a 40-hour OSHA training course in Hazardous Waste Operations and Emergency Response (HAZWOPER), and will have previously worked at least 3 days at a hazardous waste site. The 40-hour OSHA training course must be designed to meet the requirements of 29 CFR 1920.120. In addition, field personnel who completed their 40-hour HAZWOPER training more than 1 year prior to the start of field activities will have completed an annual 8-hour refresher course.

All subcontractor personnel will be required to show proof of current OSHA HAZWOPER training (less than 1 year since initial or refresher training) prior to field activities. Personnel without current training documentation will be barred from site activities.

3.2 Medical Surveillance

All site workers will be required to have a written statement from a licensed physician stating they have had a medical examination which meets the requirements of 29 CFR 1910.120. This examination must include pulmonary function testing as well as certification by the physician of the employee's ability to wear a negative-pressure respirator and perform strenuous work. If a person sustains an injury or contracts an illness related to work on site that results in lost work time, he/she must obtain written approval from a physician to regain access to the site.

3.3 Record Keeping

Air monitoring via industrial hygiene monitoring or direct-reading instruments will become part of the written record. Medical and air monitoring data will be retained for 30 years. Training records will be maintained in project files and will be available for inspection at any time. Subcontractor training and medical surveillance certification will also be maintained in project files.

SECTION 4.0

HAZARD EVALUATION

4.1 Chemical Hazards

Based on data collected from soil and groundwater sampling at the site during the Phase I RI in 1996 and 1997, the suspected chemical hazards at the Seattle ANGS are VOCs (primarily TCE) and TPH. These substances may exist in soil and/or groundwater at the site.

4.1.1 Volatile Organic Compounds

Most VOCs, except those known to be carcinogenic, exhibit similar health effects in humans. Effects on the central nervous and upper respiratory systems and skin irritation predominate. Therefore, although the hazards of several common VOCs are described separately below, the potential additive effects of multiple compounds were considered in determining air monitoring action levels.

Trichloroethylene. TCE is a colorless, low-flammability liquid with a chloroform-like odor. It is toxic to the central nervous system and is also a carcinogen. Inhalation of TCE can cause narcosis, headache, drowsiness, hallucinations, and distorted perception. At high concentrations, inhalation can cause unconsciousness or death due to cardiac arrest. TCE vapor is irritating to the eyes, nose, respiratory tract, and skin. Chronic exposure may cause heart, liver, and kidney damage. The current OSHA and Washington State Time-Weighted Average (TWA) Permissible Exposure Limit (PEL) for TCE vapor is 50 parts per million (ppm). The short term (15-minute) exposure limit (STEL) is 200 ppm.

Tetrachloroethylene. PCE is a colorless, non-combustible liquid with a mild, chloroform-like odor. It is toxic to the central nervous system and is also a carcinogen. Exposure to PCE can adversely effect functioning of the mucous membranes, eyes, lungs, liver, kidney, and heart. Common symptoms of exposure include dizziness, headache, light-headedness, and possibly unconsciousness. Skin contact may cause a dry, scaly, itchy

dermatitis. Recent studies suggest that PCE can cause liver cancer in rats and mice. The current OSHA and Washington State TWA PEL for PCE vapor is 25 ppm.

1,2-Dichloroethylene (1,2-DCE). 1,2-DCE is a colorless, flammable liquid with a slightly acrid, chloroform-like odor. It is toxic to the central nervous system and is also a suspected human carcinogen. 1,2-DCE vapor is irritating to the eyes, nose, and respiratory tract. At high concentrations, it has caused liver and kidney damage in laboratory animals. The current OSHA TWA PEL for 1,2-DCE vapor is 200 ppm.

Benzene. Benzene is a known human carcinogen that can cause leukemia via chronic exposure. It is a severe eye and moderate skin irritant. Human effects by inhalation and ingestion include: euphoria, changes in sleep and motor activity, nausea and vomiting, other blood effects, dermatitis and fever. Inhalation is the primary route of chronic benzene poisoning; however, poisoning by skin contact has also been reported. The current OSHA and Washington State TWA PEL for benzene vapor is 1 ppm. The STEL is 5 ppm.

Toluene. Human systemic effects of exposure to toluene include: central nervous system changes, hallucinations or distorted perceptions, motor activity changes, psychophysiological changes and bone marrow changes. It is a severe eye irritant and an experimental teratogen. The current OSHA and Washington State TWA PEL for toluene vapor is 100 ppm. The STEL is 150 ppm.

Ethylbenzene. Ethylbenzene is mildly toxic by inhalation and skin contact. Inhalation can cause eye, sleep and pulmonary changes. It is also an eye and skin irritant. At high concentrations, it can cause dizziness, irritation of the nose and throat, and a sense of constriction in the chest. The current OSHA TWA PEL for ethylbenzene vapor is 100 ppm. The STEL is 125 ppm.

Xylene. Xylene is toxic to the central nervous system and is an eye, nose, throat, and skin irritant. Chronic exposure can cause damage to the gastrointestinal tract, blood, liver, and kidneys. The current OSHA and Washington State TWA PEL for xylene vapor is 100 ppm. The STEL is 150 ppm.

Methylene chloride. Methylene chloride is a colorless, combustible liquid with a chloroform-like odor. It is toxic to the cardiovascular and central nervous systems and is also a carcinogen. Methylene chloride vapor is irritating to the eyes and skin. Common symptoms of exposure include

weakness, fatigue, sleepiness, lightheadedness, numbness or tingling of the limbs, and nausea. The current Washington State TWA PEL for methylene chloride vapor is 25 ppm; the OSHA TWA PEL is 500 ppm.

Table 4-1 provides a summary of the exposure information for the compounds identified above.

4.1.2 Petroleum Hydrocarbons

Most petroleum hydrocarbons exhibit similar health effects in humans. Effects on the central nervous and upper respiratory systems and skin irritation predominate. The hazards of several common petroleum products are described separately below.

Gasoline. Gasoline varies in composition, but, in general, consists of hexanes, heptanes, octanes, and aromatic hydrocarbons. Exposure to gasoline can produce narcotic effects such as dizziness, headaches, and giddiness similar to alcohol intoxication. Gasoline is also an irritant to the mucous membranes and can irritate the eyes, throat, and skin. The current Washington State TWA PEL for gasoline vapor is 300 ppm. The STEL is 500 ppm.

Exposed skin should be washed promptly with soap and water, and eyes should be flushed immediately with eyewash solution for a minimum of 15 minutes. Ingestion warrants immediate medical attention.

Diesel. Diesel is a mixture of hydrocarbons, chiefly of the methane series having 10 to 16 carbon atoms per molecule. It is a severe skin irritant with systemic effects by ingestion. It is combustible when exposed to heat or flame and can react with oxidizing materials. The vapor is also moderately explosive when exposed to heat or flame.

Heavy Oils. Heavy oils, including lubricants, grease, and motor and hydraulic oils, have been shown to cause skin cancer during prolonged dermal exposure in laboratory animals. Therefore, dermal protection must be provided when contact with heavy oil is suspected. Exposed skin should be washed as soon as possible.

Table 4-1 provides a summary of the exposure information for the substances identified above.

TABLE 4-1

*Exposure Information for Selected Potential Site Compounds
143rd CCSQ, Seattle ANG, Seattle, Washington*

Compound	OSHA PEL/WA PEL/STEL (ppm)	Physical Description	Routes of Exposure	Symptoms of Exposure	Air Monitoring Instrument
Gasoline	None/300/500	Clear to amber liquid with an aromatic odor.	Inh, Ing, Con	CNS depression; eye, nose, and throat irritation.	PID/FID
Diesel	None	Red-amber liquid, fuel odor.	Inh, Ing, Con	CNS depression; eye irritation.	PID/FID
Heavy Oils	None	Dark brown or black liquid, petroleum odor.	Ing, Con	Skin irritation.	PID/FID, Visual
Benzene	1/1/5	Colorless liquid with an aromatic odor.	Inh, Abs, Ing, Con	Skin, eye, nose, and throat irritation; dermatitis.	PID/FID
Toluene	100/100/150	Colorless liquid with a sweet, pungent, benzene-like odor.	Inh, Abs, Ing, Con	CNS depression; dilated pupils, nervousness, fatigue.	PID/FID
Ethylbenzene	100/None/125	Colorless liquid with a chloroform-like odor.	Inh, Ing, Con	CNS depression; eye, nose, and throat irritation.	PID/FID
Xylene	100/100/150	Colorless liquid with an aromatic odor.	Inh, Abs, Ing, Con	CNS depression; skin, eye, nose, and throat irritation; nausea, vomiting.	PID/FID

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TABLE 4-1 (cont.)

*Exposure Information for Selected Potential Site Compounds
143rd CCSQ, Seattle ANG, Seattle, Washington*

Compound	OSHA PEL/WA PEL/STEL (ppm)	Physical Description	Routes of Exposure	Symptoms of Exposure	Air Monitoring Instrument
TCE	50/50/200	Colorless liquid with a chloroform-like odor. Sometimes dyed blue.	Inh, Abs, Ing, Con	Headache, vertigo; visual distortion, tremors, nausea, vomiting; eye and skin irritation; cardiac arrhythmia.	PID/FID
PCE	25/25/None	Colorless liquid with a mild, chloroform-like odor.	Inh, Ing, Con	Eye, nose, and throat irritation; nausea; flushed face and neck; vertigo, dizziness, incoherence; headache.	PID/FID
1,2-DCE	200/None/None	Colorless liquid with a slightly acrid, chloroform-like odor.	Inh, Ing, Con	CNS depression; eye and respiratory system irritation.	PID/FID
Methylene Chloride	500/25/None	Colorless liquid with a chloroform-like odor.	Inh, Ing, Con	Fatigue, weakness, sleepiness, lightheadedness; numbness or tingling of limbs; nausea; eye and skin irritation.	PID/FID

ppm = Parts per million
 Inh = Inhalation
 Ing = Ingestion
 Con = Skin and/or eye contact
 Abs = Skin absorption
 PID = Photoionization detector
 FID = Flame ionization detector

OSHA = Occupational Safety and Health Administration
 PEL = Permissible Exposure limit
 STEL = Short Term Exposure Limit
 WA = Washington
 TCE = Trichloroethylene
 PCE = Tetrachloroethylene
 DCE = Dichloroethylene

4.2 Physical Hazards

Physical hazards associated with site activities include slips, trips, falls, contact and crushing type injuries, eye abrasions, contusions, lacerations, flammability, and heat stress concerns. The potential for such hazards necessitates the use of safety shoes or boots, eye goggles or safety glasses, and hard hats. Additionally, personnel engaged in work activities with the potential for hand or finger injuries are to wear sturdy work gloves.

4.2.1 Use of Equipment

Any equipment, including vehicles, winches, or other machinery will be operated in strict compliance with the manufacturer's instructions, specifications, and limitations as well as any applicable regulations. The operator is responsible for inspecting the equipment daily to ensure that it is functioning properly and safely. This inspection will include all pins, pulleys, and connections subject to accelerated wear and all lubrication points.

When equipment with moving booms, arms, or masts are operated in the vicinity of overhead hazards, the operator, with assistance from the designated signaling person, will ensure that the moving parts of the equipment maintain safe clearances to the hazards. Equipment will be kept at least 20 feet away from energized electrical lines.

All portable equipment and tools will be inspected prior to each day's use and as often as necessary to ensure that it is safe to use. Defective equipment and tools will be removed from service immediately. Examples of defective tools include: hooks and chains stretched beyond allowable deformations; cables and ropes with more than the allowable number of broken strands; missing grounding prongs on power tools; defective on/off switches; mushroomed heads of impact tools; sprung wrench jaws; and missing or broken handles or guards as well as wooden handles which are cracked, splintered, or loose. All equipment and tools will be used within their rated capacities and capabilities.

4.2.2 Flammability Hazards

Due to the nature of this project, the hazards associated with flammability are expected to be low. However, the following good management practices shall apply at the site.

All electrical equipment used during the project will be inspected to ensure that it is in good repair and has no frayed or loose connections before use on site. Only approved, listed equipment and components will be used. All connections will be made in accordance with National Electric Code practices. All equipment and devices so designed will be properly grounded or bonded to an adequate grounding mechanism. Although explosive limits are not expected, only equipment listed as explosion proof will be used in areas where explosivity is sustained at or above 5 percent of the LEL.

4.2.3 Heat Stress Concerns

Heat stress is the combination of both environmental and physical work factors that contribute to the total heat load imposed on the body. Environmental factors that contribute to heat stress include air temperature, radiant heat exchange, air movement, and humidity.

The body's response to heat stress is reflected in the degree of symptoms. When the stress is excessive for the exposed individual, a feeling of discomfort or distress may result and a heat-related disorder may ensue. The severity of the response will depend not only on the magnitude of the prevailing stress, but also on the age, physical fitness, degree of acclimatization, and dehydration of the worker.

Heat stress is a general term used to describe one or more of the following heat-related disabilities and illnesses.

Heat Cramps. Painful, intermittent spasms of the voluntary muscles following hard physical work in a hot environment. Cramps usually occur after heavy sweating and often begin at the end of a work shift.

Heat Exhaustion. Profuse sweating, weakness, rapid pulse, dizziness, nausea, and headache. The skin is cool and sometimes pale and clammy with sweat. Body temperature is normal or subnormal. Nausea, vomiting, and unconsciousness may occur.

Heat Stroke. Sweating is diminished or absent. The skin is hot, dry, and flushed. Increased body temperature, if uncontrolled, may lead to

delirium, convulsions, coma, and even death. Medical attention is needed immediately.

Workers will be trained on the signs and symptoms of the forms of heat stress and will be encouraged to monitor themselves and others. In addition, experience has shown that the following work/rest regimen is appropriate for field workers performing various degrees of work while wearing Level D PPE (all values are given in °C Wet Bulb Globe Temperature [WBGT]):

Work/Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous Work	30.0	26.7	25.0
75% work/25% rest each hour	30.6	28.0	25.9
50% work/50% rest each hour	31.4	29.4	27.9
25% work/75% rest each hour	32.2	31.1	30.0

WBGT is defined according to the following formula (outdoors with solar load) where WB, GT, and DB are the wet bulb, globe, and dry bulb temperatures, respectively:

$$WBGT = 0.7WB + 0.2GT + 0.1DB$$

The workload classes are defined in The American Conference of Governmental Industrial Hygienists booklet, "Threshold Limit Values and Biological Exposure Indices for 1995-1996."

4.2.4 Cold Stress Concerns

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental

air temperatures or from immersion in low temperature water. Cold stress (hypothermia) and cold injury can be avoided by preventing a fall in the deep core temperature of the body.

Symptoms of hypothermia include increases in metabolic rate in an attempt to compensate for the heat loss and shivering. Workers should be protected from exposure to cold so that the deep core temperature does not fall below 36° C (96.8° F). Lower body temperatures can result in reduced mental alertness, reduction in rational decision making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering develops when the body's temperature has fallen to 35° C (95° F). **Exposure to cold shall be immediately terminated for any worker when severe shivering becomes evident.**

The body must be protected from exposure to cold air temperatures via whole body protection:

- Adequate insulating clothing must be provided to workers if work is performed in air temperatures below 40° F.
- Older workers or workers with circulatory problems must be provided with extra insulating clothing and/or a reduction in the duration of exposure.
- Gloves shall be used by all workers if the air temperature falls below 40° F.

To prevent frostbite, workers should wear insulating gloves when contact with cold surfaces below 20° F are possible. Mittens are required if the air temperature falls below 0° F.

If insulating clothing is not adequate to prevent sensations of excessive cold or frostbite, auxiliary heaters or suspension of work is required.

SECTION 5.0

EXPOSURE MONITORING PLAN**5.1 Area and Personal Monitoring**

Air monitoring will be conducted to determine the presence of on-site hazardous conditions and will help determine the level of personal protection required for personnel. Environmental monitoring equipment will include a photoionization detector (PID) or a flame ionization detector (FID) for volatile organics and, if necessary, a Mini-RAM for dusts. Characterization with these instruments will determine airborne contaminants present and their concentrations in the workplace and will help assess worker safety.

5.1.1 General Area Monitoring

Area air monitoring will be conducted during all field work. The intent is to utilize generic field instruments and action levels to assess the continuous exposure to field personnel during the investigation, and to upgrade or downgrade PPE in response to the monitoring. The general monitoring shall consist of daily breathing zone monitoring every 30 minutes using the PID or FID and Mini-RAM (if applicable). In addition, upon unlocking each monitoring well, the well headspace will be monitored using a PID or FID. Daily calibration checks and maintenance of the PID or FID and Mini-RAM will also be recorded and performed according to the manufacturer's recommendations (see Appendix A for calibration documentation sheet). Breathing zone readings will be recorded in the field log book.

5.2 Action Levels

The SHO will establish daily background total organic vapor (TOV) levels (and dust levels, if necessary) prior to initiating site activities. Under most circumstances, these levels can be determined by taking multiple readings

at representative locations along the perimeter of the site and averaging the results of sustained measurements.

Decisions to upgrade or downgrade personal protection will be based on sustained breathing zone TOV and/or dust levels that exceed background levels, as well as applicable regulatory exposure limits. Breathing zone refers to the area from the top of the shoulders to the top of the head. Specific criteria for upgrading or downgrading personal protection based on TOV and dust levels are presented in the following table.

Sustained Breathing Zone TOV (ppm) and dust (mg/m³)	Level of Protection
Background + 5 ppm Background + 0.5 mg/m ³	Level-D (no respiratory protection)
5 ppm to 20 ppm 0.5 mg/m ³ to 2.5 mg/m ³	Level-C w/ half-face respirator (half face air-purifying respirator [APR] equipped with organic vapor/high efficiency particulate air [HEPA] cartridges)
20 ppm to 50 ppm 2.5 mg/m ³ to 5.0 mg/m ³	Level-C w/ full-face respirator (full-face APR equipped with organic vapor/HEPA cartridges)
Above 50 ppm or 5.0 mg/m ³	Level-B (supplied-air respirators)

SECTION 6.0

GENERAL SAFE WORK PROCEDURES**6.1 Personal Protection**

In addition to the respiratory protection described in Section 5.0, the minimum PPE available on site shall include chemical resistant coveralls, hard hats, eye protection (i.e., safety glasses), ear plugs, inner latex or PVC gloves, outer nitrile gloves, and safety boots. It is expected that the highest level of protection which may be needed during field investigation activities will be Level C. Level C protection consists of the following:

- Full length shirt and long pants;
- Steel-toed boots or safety shoes;
- Safety glasses;
- Hard hat;
- Air-purifying respirator equipped with appropriate filter cartridges;
- Chemical resistant clothing (e.g., Tyvek, poly-coated Tyvek or Saranax suits). Suits are to be one-piece with attached hoods and elastic wrist bands;
- Outer chemical resistant gloves and inner latex surgical gloves; and
- Chemical-resistant overboots.

6.2 Work Zones and Decontamination Procedures

Work zones and decontamination procedures will be established in accordance with guidance provided in Chapters 9 and 10 of the NIOSH/OSHA/USCG/EPA document *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*. Where applicable, the

exclusion zones will be marked with yellow caution tape. The location of the zones may be modified to fit applicable field conditions; however, proposed modifications must be approved by the HSO.

If necessary, a minimum two-basin wash/rinse station will be placed in the contamination/reduction zone to facilitate cleaning and removal of PPE. The wash/rinse station will be used by workers to clean and rinse boots and gloves. The ground beneath these basins will be covered with plastic to ensure the ground is not contaminated with basin wash/rinse water. A drum or other container will be designated to dispose of PPE that will not be reused.

It is expected that the highest level of protection used during project investigation activities will be Level C. Based on the level of expected exposure to chemical constituents, some or all of the following personnel decontamination procedures will be used as necessary:

- Station 1: Equipment Drop - Deposit equipment used on site (e.g., tools, sampling devices and containers, monitoring instruments, radios, and clipboards) on plastic drop cloths. Segregation at the drop station reduces the probability of cross-contamination. During hot weather operations, a cool-down station may be set up within this area.
- Station 2: Outer Garment, Boots, and Gloves Wash and Rinse - Scrub outer boots and gloves, and splash suit with decon solution or detergent water. Rinse off using copious amounts of water.
- Station 3: Outer Boot and Glove Removal - Remove outer boots and gloves. Deposit in container with plastic liner.
- Station 4: Canister or Mask Change - If worker leaves exclusion zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers are donned, joints are taped, and worker returns to duty.
- Station 5: Boots, Gloves, and Outer Garment Removal - Boots, chemical-resistant splash suit, and inner gloves are removed and deposited in separate containers lined with plastic.
- Station 6: Face Piece Removal - Face piece is removed. Avoid touching face with fingers. Face piece is deposited on plastic sheet.

- Station 7: Field Wash - Hands and face are thoroughly washed. Shower if body contamination is suspected.

All personnel must follow the appropriate order for cleansing and removal during decontamination: boots, outer gloves, coveralls or protective suit, respirators, and inner gloves. Direct contact with contaminated PPE can be avoided by a proper decontamination sequence. Respirators, if used, are not to be removed before leaving the contaminated area to avoid a potential inhalation hazard during decontamination.

Water, soap, and paper towels will be available for cleaning of hands and face before breaks, eating, drinking, or smoking.

6.3 General Safety Rules

In addition to the specific requirements of this SSHP, common sense should prevail at all times. The following general safety rules and practices will be in effect at the site.

- The site will be suitably marked or barricaded as necessary to prevent unauthorized visitors, but will not hinder emergency services, if needed.
- All open holes, excavations, trenches, and obstacles will be properly barricaded in accordance with local site needs. These needs will be determined by proximity to traffic ways, both pedestrian and vehicular, and site of the hole, trench, or obstacle. If holes are required to be left open during nonworking hours, they will be adequately decked over or barricaded and sufficiently lighted.
- Prior to conducting any digging or boring operations, underground utility locations will be identified. The site representative and local utility authorities (or Underground Alert) will be contacted to provide locations of underground utility lines and product piping. All boring, excavation, and other site work will be planned and performed with consideration for underground lines.
- Smoking and ignition sources in the vicinity of flammable or contaminated material is prohibited. Designated smoking areas will be delineated.

- Drilling, boring, movement and use of cranes and drilling rigs, erection of towers, movement of vehicles, and equipment as well as other activities will be planned and performed with consideration for the location, height, and relative position of aboveground utilities and fixtures, including signs, lights, canopies, buildings, other structures, and construction as well as natural features such as trees, boulders, bodies of water, and terrain.
- When working in areas where flammable vapors may be present, particular care must be exercised with tools and equipment that may be sources of ignition. All tools and equipment so provided must be properly bonded and/or grounded.
- Individuals with beards that interfere with respirator fit are not allowed within the exclusion zone. This is necessary because all site personnel may be called upon to use respirator protection in some situations, and beards do not allow for proper respirator fit.
- No smoking, eating, or drinking will be allowed in the contaminated areas.
- Tools and hands must be kept away from the face.
- Personnel should shower as soon as possible after leaving the site.
- Each environmental sample must be treated and handled as though it were extremely toxic.
- Do not touch obvious contaminated materials. Avoiding contact with these materials will facilitate decontamination.
- Persons with long hair and/or loose-fitting clothing that could become entangled in power equipment are not permitted in the work area.
- Horseplay is prohibited in the work area. The SHO has the authority to discharge site personnel for horseplay.
- Work while under the influence of intoxicants, narcotics, or controlled substances is prohibited.

Prior to the commencement of each day's activities, the HSO will conduct a daily tailgate safety meeting outlining new or potential hazards that may be encountered during site operations. The daily tailgate safety meetings will be documented by completion of the appropriate form located in the Attachment to this document.

SECTION 7.0

EMERGENCY RESPONSE/ACCIDENT INVESTIGATION

The phone numbers of the police and fire departments, ambulance services, local hospital, and ERM representatives are provided on the reference sheet at the front of this SSHP. Directions to the hospital are also provided on the sheet.

In the event of a health or safety emergency at the site, appropriate emergency measures will immediately be taken to assist those who have been injured or exposed and to protect others from hazards. The HSO will be immediately notified and will respond according to the seriousness of the injury. Personnel trained in first aid will be present during site activities to provide appropriate treatment of injuries or illnesses incurred during operations. The ERM Project Manager and Site Manager shall be immediately informed of any serious injuries.

Any accident/incident resulting in an OSHA recordable injury or illness, treatment at a hospital or physician's office, property damage, or a near miss accident, requires that an accident/incident report be completed and submitted to the ERM DISH. The investigation will be initiated as soon as emergency conditions are under control. The purpose of this investigation is not to assign blame but to determine the pertinent facts so that repeat or similar occurrences can be avoided.

7.1 Planning

Prior to facility entrance, the SHO shall plan emergency actions and discuss them with personnel conducting project work. Initial planning includes establishing the best means for evacuation from the area in case of a catastrophe.

7.2 Emergency Services

A tested system must exist for rapid and clear distress communications, preferably voice, from all personnel to the SHO. The SHO shall ensure that all personnel working at the facility know how to communicate with the appropriate local emergency response units as well as provide adequate and clear directions between work locations and the locations of support personnel, prior to commencing any facility investigation or operations. Emergency response contacts and telephone numbers are included on the emergency reference sheet.

7.3 General Evacuation Plan

In case of fire, explosion, or toxic vapor release and a site evacuation is ordered by the SHO:

- Announce the evacuation via radio/horn and notify ANG personnel and others in site buildings, then immediately call 911;
- Evaluate the immediate situation and downwind direction. All personnel will evacuate in the upwind direction;
- All personnel will assemble in an upwind area when the situation permits, and a head count will be taken by the SHO; and
- Await the arrival of qualified local emergency response personnel.

7.4 First Aid

Qualified personnel on site shall give first aid and stabilize any worker needing assistance. Life support techniques such as cardiopulmonary resuscitation and treatment of life-threatening problems such as bleeding, airway maintenance, and shock shall be given top priority. Professional medical assistance shall be obtained at the earliest possible opportunity. If assistance beyond first aid is required, call 911 and request emergency medical assistance.

A first-aid kit and emergency 16-ounce eye wash station shall be maintained readily accessible to all workers. The 16-ounce eyewash

station should be supplemented by a nearby 15-minute eyewash station. Prior arrangements must be made to facilitate easy access (preferably within 10 seconds of the work area) to this 15-minute eyewash station.

Emergency first aid for organic compounds is outlined below.

7.4.1 Eyes

Flush eyes immediately with fresh water for at least 15 minutes while holding the eyelids open. If injury occurs or irritation persists, transport person to a hospital emergency room as soon as possible.

7.4.2 Skin

Wash skin thoroughly with soap and water. See a doctor if any unusual signs or symptoms or skin irritation occurs. Launder chemically-impacted clothing.

7.4.3 Inhalation

Move exposed person to fresh air. If breathing has stopped, apply artificial respiration. Call 911 immediately.

7.4.4 Ingestion

If swallowed, DO NOT make person vomit. Call Poison Control Center immediately.

7.5 Fire Protection and Response

To ensure that fire and explosion hazards are minimized, field procedures involving potential fire/explosion hazards must be coordinated with the local Fire Department. Call 911 in the event of any fire at a work location. At least one fire extinguisher with a minimum class rating of 20BC shall be provided within 50 feet of the site activities. The fire extinguisher will be inspected annually at a minimum, and the inspections will be documented on an attached fire extinguisher inspection tag.

Potential fire sources/flammable materials that may be present on site during field work include gasoline and/or diesel stored in vehicle fuel

tanks, portable generator fuel tanks, and small fuel cans (for refueling portable generators). In addition, small quantities of methanol will be used for sampling equipment decontamination. Containers for flammable materials will be inspected for possible leaks or overfills at least once per day, and corrective actions will be taken as necessary to repair or replace leaking containers or to clean overfill residual from the outside of containers. Care will be taken to keep flammable materials away from potential ignition sources.

7.6 Site Control Measures

The site control measures listed below are to be followed to minimize the potential contamination of workers, protect the public from potential site hazards, and control site access.

Barricades and barricade tape will be used to delineate an exclusion zone around drilling areas. An opening in the barricades upwind of the equipment will serve as an entry and exit point. A personnel decontamination station will be established at this point. All access to the drilling location will be made at the entry and exit point.

The site will be barricaded or otherwise made secure at the end of each workday. Soils will be drummed or placed on plastic and covered. Decontamination fluids will be drummed and properly labeled.

The SHO will log all site visitors in the field notebook and will ensure that all personnel entering the work zone are briefed on site activities and potential hazards.

7.7 Site Operation Zones

The following three Site Operation Zones will be established at each investigation site:

- Exclusion zone;
- Contamination reduction zone; and
- Support zone.

The exclusion zone includes areas of active investigation or cleanup. Prescribed levels of protection must be worn by all personnel within the exclusion zone. The boundary of the exclusion zone should be a well defined physical or geographical barrier.

The contamination reduction zone serves to prevent the transfer of hazardous materials picked up on personnel or equipment in the exclusion zone.

The support zone is the outermost area and is considered a non-contaminated area. The field operations command post, first aid station, and any other investigation support activities are located in the support zone. Potentially contaminated equipment is not allowed in this area.

7.8 Emergency Operation Shutdown Procedures

In the event an extremely hazardous situation develops on site, the SHO may temporarily suspend operations until the situation is corrected or controlled. The SHO will have the authority to restart operations when the situation has been corrected and safe working conditions have been restored.

7.9 Spill or Hazardous Material Release

Spills or hazardous material releases resulting in human exposure or off-site environmental contamination are reported to the appropriate authorities by the SHO. Small spills are reported to the SHO and are taken care of per the chemical manufacturers' recommended procedures.

7.10 Community Safety

Release or off-site migration of contaminants during field operations is unlikely. However, in the event of a significant release of contaminants during field work, the proper state and local authorities will be immediately notified. Appropriate actions will be taken to protect the public and control the contaminant release or migration.

ATTACHMENT 1



SAFETY AND HEALTH FORMS

The following signatures indicate that the Safety and Health Program has been read and accepted by ERM management and personnel as well as all contractors and subcontractors and their personnel.

[illegible]

SUPERVISOR'S ACCIDENT/INCIDENT INVESTIGATION REPORT

Injured Employee:		Title:	
Date of Accident/Incident:		Dept.:	
Location:		Time on this Job:	
Engaged in what work when injured:			
Nature of accident/incident:			
How did accident/incident occur?			
What can be done to prevent recurrence of the accident?			
What has been done to prevent recurrence of the accident?			
Supervisor's Signature:		Dept.:	Date:
Reviewer's Signature:		Dept.:	Date:
NOTE: To be submitted to the Safety and Health Manager within 2 days of the accident/incident.			

ERM
DAILY TAILGATE SAFETY MEETING FORM

DATE:_____ TIME:_____ JOB NUMBER:_____
PROJECT NAME: _____
SPECIFIC LOCATION: _____
TYPE OF WORK: _____
CHEMICALS PRESENT: _____

SAFETY TOPICS DISCUSSED

Protective Clothing/Equipment: _____

Hazards of Chemicals Present: _____

Physical Hazards: _____

Emergency Procedures: _____

Hospital/Clinic:_____ Phone: _____ Paramedics: _____
Hospital Address: _____

Special Hazards: _____

Other Topics: _____

ATTENDEES

Name (printed)

Signature

ATTACHMENT 2

MATERIAL SAFETY DATA SHEETS



Genium Publishing Corporation

One Genium Plaza
Schenectady, NY 12304-4690 USA
(518) 377-8854

Material Safety Data Sheets Collection:

Sheet No. 312
Trichloroethylene

Issued: 7/79

Revision: F, 9/92

Section 1. Material Identification

Trichloroethylene (C₂HCl₃) Description: Derived by treating tetrachloroethane with lime or other alkali in the presence of water, or by thermal decomposition of tetrachloroethane followed by steam distillation. Stabilizers such as epichlorohydrin, isobutanol, carbon tetrachloride, chloroform, benzene, or pentanol-2-triethanolamine are then added. Used as a degreasing solvent in electronics and dry cleaning, a chemical intermediate, a refrigerant and heat-exchange liquid, and a diluent in paint and adhesives; in oil, fat, and wax extraction and in aerospace operations (flushing liquid oxygen). Formerly used as a fumigant (food) and anesthetic (replaced due to its hazardous decomposition in closed-circuit apparatus).
Other Designations: CAS No. 79-01-6; acetylene trichloride; Algylen; Anamenth; Benzinol; Cecolene; Chlorlylen; Dow-Tri; ethylene trichloride; Germalgene; Narcogen; Triasol; trichloroethene; TCE; 1,1,3-trichloroethylene.
Manufacturers: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*⁽⁷³⁾ for a suppliers list.

R 1
I 2
S 2*
K 3
* Skin absorption

NFPA
2 0
2

HMIS
H 2†
F 2
R 0
PPE†
† Chronic Effects
‡ Sec. 8

Cautions: TCE is irritating and toxic to the central nervous system (CNS). Inhalation of high concentrations have lead to death due to ventricular fibrillation. Chronic exposure may lead to heart, liver, and kidney damage. The liquid is absorbed through the skin. Although it has a relatively low flash point, TCE burns with difficulty.

Section 2. Ingredients and Occupational Exposure Limits

Trichloroethylene, < 100% [contains stabilizers (Sec. 1)].

1991 OSHA PELs
8-hr TWA: 50 ppm (270 mg/m³)
15-min STEL: 200 ppm (1080 mg/m³)

1992-93 ACGIH TLVs
TWA: 50 ppm (269 mg/m³)
STEL: 200 ppm (1070 mg/m³)

1990 IDLH Level
1000 ppm

1990 DFG (Germany) MAK
Ceiling: 50 ppm (270 mg/m³)
Category II: Substances with systemic effects
Half-life: 2 hr to shift length
Peak Exposure Limit: 250 ppm, 30 min
average value; 2 peaks/shift

1985-86 Toxicity Data*

Human, inhalation, TC₅₀: 160 ppm/83 min caused hallucinations and distorted perceptions.
Human, lymphocyte: 5 mL/L caused DNA inhibition.
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.
Mouse, oral, TD₅₀: 455 mg/kg administered intermittently for 78 weeks produced liver tumors.

* See NIOSH, RTECS (KX4550000), for additional irritation, mutation, reproductive, tumorigenic and toxicity data.

Section 3. Physical Data

Boiling Point: 189 °F (87 °C)
Freezing Point: -121 °F (-85 °C)
Viscosity: 0.0055 Poise at 77 °F (25 °C)
Molecular Weight: 131.38
Density: 1.4649 at 20/4 °C
Refraction Index: 1.477 at 68 °F (20 °C/D)
Odor Threshold: 82 to 108 ppm (not an effective warning)

Vapor Pressure: 58 mm Hg at 68 °F (20 °C); 100 mm Hg at 32 °F (0 °C)
Saturated Vapor Density (Air = 0.075 lbs/ft³; 1.2 kg/m³): 0.0956 lbs/ft³; 1.53 kg/m³
Water Solubility: Very slightly soluble; 0.1% at 77 °F (25 °C)
Other Solubilities: Highly soluble in organic solvents (alcohol, acetone, ether, carbon tetrachloride, & chloroform) and lipids.
Surface Tension: 29.3 dyne/cm

Appearance and Odor: Clear, colorless (sometimes dyed blue), mobile liquid with a sweet chloroform odor.

Section 4. Fire and Explosion Data

Flash Point: 90 °F (32 °C) CC [Autoignition Temperature: 788 °F (420 °C)] LEL: 8% (25 °C); 12.5% (100 °C) UEL: 10% (25 °C); 90% (100 °C)

Extinguishing Media: A Class 1C Flammable Liquid. Although it has a flash point of 90 °F, TCE burns with difficulty. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. Unusual Fire or Explosion Hazards: Vapor/air mixtures may explode when ignited. Container may explode in heat of fire. Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection against TCE. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE slowly decomposes in the presence of light and moisture to form corrosive hydrochloric acid. Hazardous polymerization cannot occur. Chemical Incompatibilities: Include alkalis (sodium hydroxide), chemically active metals (aluminum, beryllium, lithium, magnesium, sodium, potassium, and titanium), epoxides, and oxidants (nitrogen tetroxide, perchloric acid). Contact with 1-chloro-2,3-epoxy propane or the mono and di 2,3-epoxypropyl ethers of 1,4-butanediol + 2,2-bis-4(2,3'-epoxypropoxy)-phenylpropane can, in the presence of catalytic quantities of halide ions, cause dehydrochlorination of TCE to explosive dichloroacetylene. Conditions to Avoid: Exposure to light, moisture, ignition sources, and incompatibles. Hazardous Products of Decomposition: Thermal oxidative decomposition of TCE (above 300 °C) or exposure to ultraviolet light can produce carbon dioxide (CO₂) and toxic dichloro acetylene (explosive), chlorine, hydrogen chloride, and phosgene gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies have rated TCE's carcinogenicity: IARC (Class 3, limited animal evidence & insufficient human data), Germany MAK (Class B, justifiably suspected of having carcinogenic potential), & NIOSH (Class X, carcinogen defined with no further categorization). Summary of Risks: TCE vapor is irritating to the eyes, nose, and respiratory tract and inhalation of high concentrations can lead to severe CNS effects such as unconsciousness, ventricular arrhythmias, and death due to cardiac arrest. Mild liver dysfunction was also seen at levels high enough to produce CNS effects. Contact with the liquid is irritating to the skin and can lead to dermatitis by defatting the skin. Chronic toxicity is observed in the victims increasing intolerance to alcohol characterized by 'degreasers flush', a transient redness of the face, trunk, and arms. The euphoric effect of TCE has led to craving, and habitual sniffing of its vapors.

Continue on next page

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Section 6. Health Hazard Data, Continued

TCE crosses the placental barrier and thus exposes the fetus (any effects are yet unknown). There are increased reports of menstrual disorders in women workers and decreased libido in males at exposures high enough to cause CNS effects. TCE is eliminated unchanged in expired air and as metabolites (trichloroacetic acid & trichloroethanol) in blood and urine. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the nervous system, skin, heart, liver, and kidney. **Target Organs:** Respiratory, central & peripheral nervous, and cardiovascular (heart) systems, liver, kidney, and skin. **Primary Entry Routes:** Inhalation, skin and eye contact, and ingestion (rarely). **Acute Effects:** Vapor inhalation can cause eye, nose, and throat irritation, nausea, blurred vision, overexcitement, headache, drunkenness, memory loss, irregular heartbeat (resulting in sudden death), unconsciousness, and death due to cardiac failure. Skin contact with the liquid can cause dryness and cracking and prolonged exposure (generally if the victim is unconscious) can cause blistering. Eye contact can cause irritation and watering, with corneal epithelium injury in some cases. Ingestion of the liquid can cause lip, mouth, and gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Effects may persist for several weeks or months after repeated exposure. Symptoms include giddiness, irritability, headache, digestive disturbances, mental confusion, intolerance to alcohol (degreasers flush), altered color perception, loss or impairment of sense of smell, double vision, and peripheral nervous system function impairment, including persistent neuritis, temporary loss of sense of touch, and paralysis of the fingers from direct contact with TCE liquid.

FIRST AID Eyes: Do not allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. Skin: Quickly remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. Inhalation: Remove exposed person to fresh air and support breathing as needed. Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that conscious and alert person drink 1 to 2 glasses of water, then induce vomiting. Do not give milk, as its fat content (TCE is lipid soluble) may enhance gastrointestinal absorption of TCE. **Note to Physicians:** TCE elimination seems to be biphasic with half-lives at 20 min, 3 hr, and 30 hr. Some success is seen in treating patients with propranolol, atropine, and disulfiram. Monitor urine and blood (lethal level = 3 to 110 µg/mL) metabolites. BEI = 100 mg/g creatinine (trichloroacetic acid) in urine, sample at end of workweek. BEI = 4 mg/L (trichloroethanol) in blood, sample at end of shift at end of the workweek. These tests are not 100% accurate indicators of exposure; monitor TCE in expired air as a confirmatory test.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container for later disposal. For large spills, flush to containment area where density stratification will form a bottom TCE layer which can be pumped and containerized. Report any release in excess of 1000 lbs. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill sunfish, $LC_{50} = 44,700 \mu\text{g/L/96 hr}$; fathead minnow (*Pimephales promelas*), $LC_{50} = 40.7 \text{ mg/L/96 hr}$. **Environmental Degradation:** In air, TCE is photooxidized with a half-life of 5 days and reported to form phosgene, dichloroacetyl chloride, and formyl chloride. In water it evaporates rapidly in minutes to hours. TCE rapidly evaporates and may leach since it does not absorb to sediment. **Soil Absorption/Mobility:** TCE has a $\log K_{oc}$ of 2, indicating high soil mobility. **Disposal:** Waste TCE can be poured on dry sand and allowed to vaporize in isolated location, purified by distillation, or returned to supplier. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) with an acid scrubber to remove halo acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Listed as a RCRA Hazardous Waste (40 CFR 261.33 & 261.31): No. U228 & F002 (spent solvent)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ): 100 lb (45.4 kg) (* per RCRA, Sec. 3001, CWA Sec. 311 (b)(4), & CWA Sec. 307 (a))

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles (cup-type or rubber framed, equipped with impact-resistant glass), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. At any detectable concentration, wear a SCBA with a full facepiece operated in pressure demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning!** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made from Viton or Neoprene to prevent skin contact. Do not use natural rubber or polyvinyl chloride (PVC). **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰⁾ **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in steel drums, in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, and incompatibles (Sec. 5). Store large quantities in galvanized iron, black iron, or steel containers; small amounts in dark (amber colored glass bottles). **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Design processes so that the operator is not directly exposed to the solvent or its vapor. Do not use open electric heaters, high-temperature processes, arc-welding or open flames in TCE atmospheres. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, respiratory, cardiac, central and peripheral nervous systems, and liver and kidney function. Employ air and biological monitoring (BEIs). Instruct employees on safe handling of TCE.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Trichloroethylene

DOT Hazard Class: 6.1

ID No.: UN1710

DOT Packing Group: III

DOT Label: Keep Away From Food

DOT Special Provisions (172.102): N36, T1

Packaging Authorizations

a) Exceptions: 173.153

b) Non-bulk Packaging: 173.203

c) Bulk Packaging: 173.241

Quantity Limitations

a) Passenger Aircraft or Railcar: 60

b) Cargo Aircraft Only: 220L

Vessel Stowage Requirements

a) Vessel Stowage: A

b) Other: 40

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.

Prepared by: M Gannon, BA; Industrial Hygiene Review: D Wilson, CDH; Medical Review: AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 467
Automotive Gasoline, Lead-free

Issued: 10/81

Revision: A, 9/91

Section 1. Material Identification

Automotive Gasoline, Lead-free, Description: A mixture of volatile hydrocarbons composed mainly of branched-chain paraffins, cycloparaffins, olefins, naphthenes, and aromatics. In general, gasoline is produced from petroleum, shale oil, Athabasca tar sands, and coal. Motor gasolines are made chiefly by cracking processes, which convert heavier petroleum fractions into more volatile fractions by thermal or catalytic decomposition. Widely used as fuel in internal combustion engines of the spark-ignited, reciprocating type. Automotive gasoline has an octane number of approximately 90. A high content of aromatic hydrocarbons and a consequent high toxicity are also associated with a high octane rating. Some gasolines sold in the US contain a minor proportion of tetraethyllead, which is added in concentrations not exceeding 3 ml per gallon to prevent engine "knock." However, methyl-tert-butyl ether (MTBE) has almost completely replaced tetraethyllead.

Other Designations: CAS No. 8006-61-9, benzin, gasoline, gasolene, motor spiritus, natural gasoline, petrol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*⁽¹⁾ for a suppliers list.

R 1
I 2
S 2*
K 4
* Skin absorption

35
NFPA
3
1 0
HMIS
H 2
F 3
R 1
PPG†
† Sec. 8

Cautions: Inhalation of automotive gasoline vapors can cause intense burning in throat and lungs, central nervous system (CNS) depression, and possible fatal pulmonary edema. Gasoline is a dangerous fire and explosion hazard when exposed to heat and flames.

Section 2. Ingredients and Occupational Exposure Limits

Automotive gasoline, lead-free*

1990 OSHA PELs

8-hr TWA: 300 ppm, 900 mg/m³

15-min STEL: 500 ppm, 1500 mg/m³

1990-91 ACGIH TLVs

TWA: 300 ppm, 890 mg/m³

STEL: 500 ppm, 1480 mg/m³

1990 NIOSH REL

None established

1985-86 Toxicity Data*

Man, inhalation, TC₅₀: 900 ppm/1 hr; toxic effects include sense organs and special senses (conjunctiva irritation), behavioral (hallucinations, distorted perceptions), lungs, thorax, or respiration (cough)

Human, eye: 140 ppm/8 hr; toxic effects include mild irritation

Rat, inhalation, LC₅₀: 300 g/m³/5 min

* A typical modern gasoline composition is 80% paraffins, 14% aromatics, and 6% olefins. The mean benzene content is approximately 1%. Other additives include sulfur, phosphorus, and MTBE.

† See NIOSH, RTECS (LX3300000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: Initially, 102 °F (39 °C); after 10% distilled, 140 °F (60 °C); after 50% distilled, 230 °F (110 °C); after 90% distilled, 338 °F (170 °C); final boiling point, 399 °F (204 °C)

Vapor Density (air = 1): 3.0 to 4.0

Density/Specific Gravity: 0.72 to 0.76 at 60 °F (15.6 °C)

Water Solubility: Insoluble

Appearance and Odor: A clear (gasoline may be colored with dye), mobile liquid with a characteristic odor recognizable at about 10 ppm in air.

Section 4. Fire and Explosion Data

Flash Point: -45 °F (-43 °C)

Autoignition Temperature: 536 to 853 °F (280 to 456 °C)

LEL: 1.3% v/v

UEL: 6.0% v/v

Extinguishing Media: Use dry chemical, carbon dioxide, or alcohol foam as extinguishing media. Use of water may be ineffective to extinguish fire, but use water spray to knock down vapors and to cool fire-exposed drums and tanks to prevent pressure rupture. Do not use a solid stream of water since it may spread the fuel.

Unusual Fire or Explosion Hazards: Automobile gasoline is an OSHA Class IB flammable liquid and a dangerous fire and explosion hazard when exposed to heat and flames. Vapors can flow to an ignition source and flash back. Automobile gasoline can also react violently with oxidizing agents.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode, and full protective clothing. When the fire is extinguished, use nonsparking tools for cleanup. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Automotive gasoline is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Automotive gasoline can react with oxidizing materials such as peroxides, nitric acid, and perchlorates.

Conditions to Avoid: Avoid heat and ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of automotive gasoline can produce oxides of carbon and partially oxidized hydrocarbons.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC list gasoline as a possible human carcinogen (Group 2B). Although the IARC has assigned an overall evaluation to gasoline, it has not assigned an overall evaluation to specific substances within this group (inadequate human evidence).

Summary of Risks: Gasoline vapors are considered moderately poisonous. Vapor inhalation can cause central nervous system (CNS) depression and mucous membrane and respiratory tract irritation. Brief inhalations of high concentrations can cause a fatal pulmonary edema. Reported responses to gasoline vapor concentrations are: 160 to 270 ppm causes eye and throat irritation in several hours; 500 to 900 ppm causes eye, nose, and throat irritation, and dizziness in 1 hr; and 2000 ppm produces mild anesthesia in 30 min. Higher concentrations are intoxicating in 4 to 10 minutes. If large areas of skin are exposed to gasoline, toxic amounts may be absorbed. Repeated or prolonged skin exposure causes dermatitis. Certain individuals may develop hypersensitivity. Ingestion can cause CNS depression. Pulmonary aspiration after ingestion can cause severe pneumonitis. In adults, ingestion of 20 to 50 g gasoline may produce severe symptoms of poisoning.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Skin, eye, respiratory and central nervous systems.

Primary Entry Routes: Inhalation, ingestion, skin contact.

Acute Effects: Acute inhalation produces intense nose, throat, and lung irritation; headaches; blurred vision; conjunctivitis; flushing of the face; mental confusion; staggering gait; slurred speech; and unconsciousness, sometimes with convulsions. Ingestion causes inebriation (drunkenness), vomiting, dizziness, fever, drowsiness, confusion, and cyanosis (a blue to dark purplish coloration of skin and mucous membrane caused by lack of oxygen). Aspiration causes choking, cough, shortness of breath, increased rate of respiration, excessively rapid heartbeat, fever, bronchitis, and pneumonitis. Other symptoms following acute exposure include acute hemorrhage of the pancreas, fatty degeneration of the liver and kidneys, and passive congestion of spleen.

Chronic Effects: Chronic inhalation results in appetite loss, nausea, weight loss, insomnia, and unusual sensitivity (hyperesthesia) of the distal extremities followed by motor weakness, muscular degeneration, and diminished tendon reflexes and coordination. Repeated skin exposure can cause blistering, drying, and lesions.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: Quickly remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* due to aspiration hazard.

Give conscious victim a mixture of 2 tablespoons of activated charcoal mixed in 8 oz of water to drink. Consult a physician immediately.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and liquid contact. Use nonsparking tools. Take up small spills with sand or other noncombustible adsorbent. Dike storage areas to control leaks and spills. Follow applicable OSHA regulations (29 CFR 1910.120).

Aquatic Toxicity: Bluegill, freshwater, LC₅₀ 8 ppm/96 hr.

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.21): Characteristic of ignitability

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. There are no specific NIOSH recommendations. However, for vapor concentrations not immediately dangerous to life or health, use chemical cartridge respirator equipped with organic vapor cartridge(s), or a supplied-air respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.**

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Materials such as neoprene or polyvinyl alcohol provide excellent/good resistance for protective clothing. Note: Resistance of specific materials can vary from product to product.

Ventilation: Provide general and local explosion-proof exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰⁾

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area away from heat and ignition sources and strong oxidizing agents. Protect containers from physical damage. Avoid direct sunlight. Storage must meet requirements of OSHA Class IB liquid. Outside or detached storage preferred.

Engineering Controls: Avoid vapor inhalation and skin or eye contact. Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Indoor use of this material requires explosion-proof exhaust ventilation to remove vapors. Only use gasoline as a fuel source due to its volatility and flammable/explosive nature. Practice good personal hygiene and housekeeping procedures. Wear clean work clothing daily.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Gasoline (including casing-head and natural)

DOT Hazard Class: Flammable liquid

ID No.: UN1203

DOT Label: Flammable liquid

DOT Packaging Exceptions: 173.118

DOT Packaging Requirements: 173.119

IMO Shipping Name: Gasoline

IMO Hazard Class: 3.1

ID No.: UN1203

IMO Label: Flammable liquid

IMDG Packaging Group: II

MSDS Collection References: 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 140, 143, 146, 153, 159

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Material Safety Data Sheets Collection:

Sheet No. 470
Diesel Fuel Oil No. 2-D

Issued: 10/81

Revision: A, 11/90

Section 1. Material Identification

Diesel Fuel Oil No. 2-D Description: Diesel fuel is obtained from the middle distillate in petroleum separation; a distillate oil of low sulfur content. It is composed chiefly of unbranched paraffins. Diesel fuel is available in various grades, one of which is synonymous with fuel oil No. 2-D. This diesel fuel oil requires a minimum Cetane No. (efficiency rating for diesel fuel comparable to octane number ratings for gasoline) of 40 (ASTM D613). Used as a fuel for trucks, ships, and other automotive engines; as mosquito control (coating on breeding waters); and for drilling muds.
Other Designations: CAS No. 68334-30-5, diesel fuel.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*^(m) for a suppliers list.

Cautions: Diesel fuel oil No. 2-D is a skin irritant and central nervous depressant with high mist concentrations. It is an environmental hazard and moderate fire risk.

33
NFPA
2
0
0
HMS
H 0
F 2
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Diesel fuel oil No. 2-D*

1989 OSHA PEL	1990-91 ACGIH TLV	1988 NIOSH REL	1985-86 Toxicity Data†
None established	Mineral Oil Mist TWA: 5 mg/m ³ † STEL: 10 mg/m ³	None established	Rat, oral, LD ₅₀ : 9 g/kg produces gastrointestinal (hypermotility, diarrhea) effects

* Diesel fuel No. 2-D tends to be low in aromatics and high in paraffinics. This fuel oil is complex mixture of: 1) >95% paraffinic, olefinic, naphthenic, and aromatic hydrocarbons, 2) sulfur (<0.5%), and 3) benzene (<100 ppm). [A low benzene level reduces carcinogenic risk. Fuel oils can be exempted under the benzene standard (29 CFR 1910.1028)]. Although low in the fuel itself, benzene concentrations are likely to be much higher in processing areas.

† As sampled by nonvapor-collecting method.

‡ Monitor NIOSH, RTECS (HZ1800000), for future toxicity data.

Section 3. Physical Data

Boiling Point Range: 340 to 675 °F (171 to 358 °C)

Viscosity: 1.9 to 4.1 centistoke at 104 °F (40 °C)

Specific Gravity: <0.86

Water Solubility: Insoluble

Appearance and Odor: Brown, slightly viscous liquid.

Section 4. Fire and Explosion Data

Flash Point: 125 °F (52 °C) min.

Autoignition Temperature: >500 °F (932 °C)

LEL: 0.6% v/v

UEL: 7.5% v/v

Extinguishing Media: Use dry chemical, carbon dioxide, or foam to fight fire. Use a water spray to cool fire exposed containers. Do not use a forced water spray directly on burning oil since this will scatter the fire. Use a smothering technique for extinguishing fire.

Unusual Fire or Explosion Hazards: Diesel fuel oil No. 2-D is a OSHA Class II combustible liquid. Its volatility is similar to that of gas oil. Vapors may travel to a source of ignition and flash back.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective clothing. If feasible, remove containers from fire. Be aware of runoff from fire control methods. Do not release to sewers or waterways due to pollution and fire or explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Diesel fuel oil No. 2-D is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: It is incompatible with strong oxidizing agents; heating greatly increases the fire hazard.

Conditions to Avoid: Avoid heat and ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of diesel fuel oil No. 2-D can produce various hydrocarbons and hydrocarbon derivatives, and other partial oxidation products such as carbon dioxide, carbon monoxide, and sulfur dioxide.

Section 6. Health Hazard Data

Carcinogenicity: Although the IARC has not assigned an overall evaluation to diesel fuels as a group, it has evaluated occupational exposures in petroleum refining as an IARC probable human carcinogen (Group 2A). It has evaluated disulfate (light) diesel oils as not classifiable as human carcinogens (Group 3).

Summary of Risks: Although diesel fuel's toxicologic effects should resemble kerosene's, they are somewhat more pronounced due to additives such as sulfonized esters. Excessive inhalation of aerosol or mist can cause respiratory tract irritation, headache, dizziness, nausea, vomiting, and loss of coordination, depending on concentration and exposure time. When removed from exposure area, affected persons usually recover completely. If vomiting occurs after ingestion and if oil is aspirated into the lungs, hemorrhaging and pulmonary edema, progressing to renal involvement and chemical pneumonitis, may result. A comparative ratio of oral to aspirated lethal doses may be 1 pt vs. 5 ml. Aspiration may also result in transient CNS depression or excitement. Secondary effects may include hypoxia (insufficient oxygen in body cells), infection, pneumatocele formation, and chronic lung dysfunction. Inhalation may result in euphoria, cardiac dysrhythmias, respiratory arrest, and CNS toxicity. Prolonged or repeated skin contact may irritate hair follicles and block sebaceous glands, producing a rash of acne pimples and spots, usually on arms and legs.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Central nervous system, skin, and mucous membranes.

Primary Entry Routes: Inhalation, ingestion.

Acute Effects: Systemic effects from ingestion include gastrointestinal irritation, vomiting, diarrhea, and in severe cases central nervous system depression, progressing to coma or death. Inhalation of aerosols or mists may result in increased rate of respiration, tachycardia (excessively rapid heart beat), and cyanosis (dark purplish discoloration of the skin and mucous membranes caused by deficient blood oxygenation).

Chronic Effects: Repeated contact with the skin causes dermatitis.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: Quickly remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. If large areas of the body have been exposed or if irritation persists, get medical help immediately. Wash affected area with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* due to aspiration hazard. Contact a physician immediately. Position to avoid aspiration.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Gastric lavage is contraindicated due to aspiration hazard. Preferred antidotes are charcoal and milk. In cases of severe aspiration pneumonitis, consider monitoring arterial blood gases to ensure adequate ventilation. Observe the patient for 6 hr. If vital signs become abnormal or symptoms develop, obtain a chest x-ray.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate area for large spills, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and liquid contact. Clean up spills promptly to reduce fire or vapor hazards. Use a noncombustible absorbent material to pick up small spills or residues. For large spills, dike far ahead to contain. Pick up liquid for reclamation or disposal. Do not release to sewers or waterways due to health and fire and/or explosion hazard. Follow applicable OSHA regulations (29 CFR 1910.120). Diesel fuel oil No. 2-D spills may be environmental hazards. Report large spills.

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.21): Ignitable waste

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, use a NIOSH-approved respirator with a mist filter and organic vapor cartridge. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.**

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations that promote worker safety and productivity. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰⁾

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Use and storage conditions should be suitable for a OSHA Class II combustible liquid. Store in closed containers in a well-ventilated area away from heat and ignition sources and strong oxidizing agents. Protect containers from physical damage. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations. Use nonsparking tools and explosion-proof electrical equipment. No smoking in storage or use areas.

Engineering Controls: Avoid vapor or mist inhalation and prolonged skin contact. Wear protective rubber gloves and chemical safety glasses where contact with liquid or high mist concentration may occur. Additional suitable protective clothing may be required depending on working conditions. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures. Do not wear oil contaminated clothing. At least weekly laundering of work clothes is recommended. Do not put oily rags in pockets. When working with this material, wear gloves or use barrier cream.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Fuel oil

DOT Hazard Class: Combustible liquid

ID No.: NA1993

DOT Label: None

DOT Packaging Exceptions: 173.118a

DOT Packaging Requirements: None

MSDS Collection References: 1, 6, 7, 12, 73, 84, 101, 103, 126, 127, 132, 133, 136, 143, 146

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Material Safety Data Sheets Collection:

Sheet No. 316
Benzene

Issued: 11/78

Revision: E, 8/90

Section 1. Material Identification

Benzene (C₆H₆) Description: Derived by fractional distillation of coal tar, hydrodealkylation of toluene or pyrolysis of gasoline, catalytic reforming of petroleum, and transalkylation of toluene by disproportionation reaction. Used as a fuel; a chemical reagent; a solvent for a large number of materials such as paints, plastics, rubber, inks, oils, and fats; in manufacturing phenol, ethylbenzene (for styrene monomer), nitrobenzene (for aniline), dodecylbenzene (for detergents), cyclohexane (for nylon), chlorobenzene, diphenyl, benzene hexachloride, maleic anhydride, benzene-sulfonic acid, artificial leather, linoleum, oil cloth, varnishes, and lacquers; for printing and lithography; in dry cleaning; in adhesives and coatings; for extraction and rectification; as a degreasing agent; in the tire industry; and in shoe factories. Benzene has been banned as an ingredient in products intended for household use and is no longer used in pesticides.

Other Designations: CAS No. 0071-43-2, benzol, carbon oil, coal naphtha, cyclohexatriene, mineral naphtha, nitration benzene, phene, phenyl hydride, pyrobenzol.

Manufacturers: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*^(TM) for a suppliers list.

R 1	NFPA
I 4	
S 2*	
K 4	
*Skin absorption	
HMIS	
H 3	
F 3	
R 0	
PPG†	
† Sec. 8	

Cautions: Benzene is a confirmed human carcinogen by the IARC. Chronic low-level exposure may cause cancer (leukemia) and bone marrow damage, with injury to blood-forming tissue. It is also a dangerous fire hazard when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Benzene, ca 100%*

1989 OSHA PELs

(29 CFR 1910.1000, Table Z-1-A)

8-hr TWA: 1 ppm, 3 mg/m³

15-min STEL: 5 ppm, 15 mg/m³

(29 CFR 1910.1000, Table Z-2)

8-hr TWA: 10 ppm

Acceptable Ceiling Concentration: 25 ppm

Acceptable Maximum Peak: 50 ppm (10 min)†

1989-90 ACGIH

TLV-TWA: 10 ppm, 32 mg/m³

1988 NIOSH RELs

TWA: 0.1 ppm, 0.3 mg/m³

Ceiling: 1 ppm, 3 mg/m³

1985-86 Toxicity Data‡

Man, oral, LD₅₀: 50 mg/kg; no toxic effect noted

Man, inhalation, TC₀₁: 150 ppm inhaled intermittently over 1 yr in a number of discrete, separate doses affects the blood (other changes) and nutritional and gross metabolism (body temperature increase)

Rabbit, eye: 2 mg administered over 24 hr produces severe irritation

* OSHA 29 CFR 1910.1000, Subpart Z, states that the final benzene standard in 29 CFR 1910.1028 applies to all occupational exposures to benzene except in some subsegments of industry where exposures are consistently under the action level (i.e., distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures); for the excepted subsegments, the benzene limits in Table Z-2 apply.

† Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift.

‡ See NIOSH, RTECS (CY1400000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 176 °F (80 °C)
Melting Point: 42 °F (5.5 °C)
Vapor Pressure: 100 mm Hg at 79 °F (26.1 °C)
Vapor Density (Air = 1): 2.7
Evaporation Rate (Ether = 1): 2.8

Molecular Weight: 78.11
Specific Gravity (15 °C/4 °C): 0.8787
Water Solubility: Slightly (0.180 g/100 g of H₂O at 25 °C)
% Volatile by Volume: 100
Viscosity: 0.6468 mPa at 20 °C

Appearance and Odor: A colorless liquid with a characteristic sweet, aromatic odor. The odor recognition threshold (100% of panel) is approximately 5 ppm (unfatigued) in air. Odor is not an adequate warning of hazard.

Section 4. Fire and Explosion Data

Flash Point: 12 °F (-11.1 °C), CC

Autoignition Temperature: 928 °F (498 °C)

LEL: 1.3% v/v

UEL: 7.1% v/v

Extinguishing Media: Use dry chemical, foam, or carbon dioxide to extinguish benzene fires. Water may be ineffective as an extinguishing agent since it can scatter and spread the fire. Use water spray to cool fire-exposed containers, flush spills away from exposures, disperse benzene vapor, and protect personnel attempting to stop an unignited benzene leak.

Unusual Fire or Explosion Hazards: Benzene is a Class 1B flammable liquid. A concentration exceeding 3250 ppm is considered a potential fire explosion hazard. Benzene vapor is heavier than air and can collect in low lying areas or travel to an ignition source and flash back. Explosive and flammable benzene vapor-air mixtures can easily form at room temperature. Eliminate all ignition sources where benzene is used, handled, or stored.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Structural firefighter's protective clothing provides limited protection. Stay out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Runoff to sewer can create pollution, fire, and explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Benzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Benzene explodes on contact with diborane, permanganic acid, bromine pentafluoride, peroxodisulfuric acid, and peroxomonosulfuric acid. It ignites on contact with dioxygen difluoride, dioxygen tetrafluoroborate, iodine heptafluoride, and sodium peroxide + water. Benzene forms sensitive, explosive mixture with iodine pentafluoride, ozone, liquid oxygen, silver perchlorate, nitryl perchlorate, nitric acid, and arsenic pentafluoride + potassium methoxide (explodes above 30 °C). A vigorous or incandescent reaction occurs with bromine trifluoride, uranium hexafluoride, and hydrogen + Raney nickel (above 410 °F (210 °C)). Benzene is incompatible with oxidizing materials.

Conditions to Avoid: Avoid heat and ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of benzene can produce toxic gases and vapors such as carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The ACGIH, OSHA, and IARC list benzene as, respectively, a suspected human carcinogen, a cancer hazard, and, based on sufficient human and animal evidence, a human carcinogen (Group 1).

Summary of Risks: Prolonged skin contact or excessive inhalation of benzene vapor may cause headache, weakness, appetite loss, and fatigue. Most important health hazards are cancer (leukemia) and bone marrow damage with injury to blood-forming tissue from chronic low-level exposure. Higher level exposures may irritate the respiratory tract and cause central nervous system (CNS) depression.

Medical Conditions Aggravated by Long-Term Exposure: Exposure may worsen ailments of the heart, lungs, liver, kidneys, blood, and CNS.

Target Organs: Blood, central nervous system, bone marrow, eyes, upper respiratory tract, and skin.

Primary Entry Routes: Inhalation, skin contact.

Acute Effects: Symptoms of acute overexposure include irritation of the eyes, nose, and respiratory tract, breathlessness, euphoria, nausea, drowsiness, headache, dizziness, and intoxication. Severe exposure may lead to convulsions and unconsciousness. Skin contact may cause a drying rash (dermatitis).

Chronic Effects: Long-term chronic exposure may result in many blood disorders ranging from aplastic anemia (an inability to form blood cells) to leukemia.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: Quickly remove contaminated clothing. Immediately rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.

Inhalation: Remove exposed person to fresh air. Emergency personnel should protect against inhalation exposure. Provide CPR to support breathing or circulation as necessary. Keep awake and transport to a medical facility.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* since aspiration may be fatal. Call a physician immediately.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Physician's Note: Evaluate chronic exposure with a CBC, peripheral smear, and reticulocyte count for signs of myelotoxicity. Follow up any early indicators of leukemia with a bone marrow biopsy. Urinary phenol conjugates may be used for biological monitoring of recent exposure.

Acute management is primarily supportive for CNS depression.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Design and practice a benzene spill control and countermeasure plan (SCCP). Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation, eye contact, and skin absorption. Absorb as much benzene as possible with an inert, noncombustible material. For large spills, dike far ahead of spill and contain liquid. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of confined spaces such as sewers, watersheds, and waterways because of explosion danger. Follow applicable OSHA regulations (29 CFR 1910.120).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations. EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U019

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307 (a), 311 (b)(4), 112; and per RCRA, Sec. 3001]

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.**

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations at least below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰⁾

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and incompatible materials. **Caution! Benzene vapor may form explosive mixtures in air.** To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. When opening or closing benzene containers, use nonsparking tools. Keep fire extinguishers readily available.

Engineering Controls: Because OSHA specifically regulates benzene (29 CFR 1910.1028), educate workers about its potential hazards and dangers. Minimize all possible exposures to carcinogens. If possible, substitute less toxic solvents for benzene; use this material with extreme caution and only if absolutely essential. Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation.

Designate regulated areas of benzene use (see legend in the box below) and label benzene containers with "DANGER, CONTAINS BENZENE, CANCER HAZARD."

Other Precautions: Provide preplacement and periodic medical examinations with emphasis on a history of blood disease or previous exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Benzene (benzol)

DOT Hazard Class: Flammable liquid

ID No.: UN1114

DOT Label: Flammable liquid

DOT Packaging Exceptions: 173.118

DOT Packaging Requirements: 173.119

IMO Shipping Name: Benzene

IMO Hazard Class: 3.2

ID No.: UN1114

IMO Label: Flammable liquid

IMDG Packaging Group: II

DANGER
BENZENE
CANCER HAZARD
FLAMMABLE-NO SMOKING
AUTHORIZED PERSONNEL ONLY
RESPIRATOR REQUIRED

MSDS Collection References: 1, 2, 12, 26, 73, 84-94, 100, 101, 103, 109, 124, 126, 127, 132, 134, 136, 138, 139, 143

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**Section 1. Material Identification**

Toluene (C₆H₅CH₃) Description: Derived from petroleum i.e., dehydrogenation of cycloparaffin fractions followed by the aromatization of saturated aromatic hydrocarbons or by fractional distillation of coal-tar light oil and purified by rectification. Used widely as a solvent (replacing benzene in many cases) for oils, resins, adhesives, natural rubber, coal tar, asphalt, pitch, acetyl celluloses, cellulose paints and varnishes; a diluent for photogravure inks, raw material for organic synthesis (benzoyl & benzilidene chlorides, saccharine, TNT, toluene diisocyanate, and many dyestuffs), in aviation and high octane automobile gasoline, as a nonclinical thermometer liquid and suspension solution for navigational instruments.

Other Designations: CAS No. 108-88-3, Methacide, methylbenzene, methylbenzol, phenylmethane, toluol, Tolu-sol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*⁽⁷³⁾ for a suppliers list.

Cautions: Toluene is an eye, skin, and respiratory tract irritant becoming narcotic at high concentrations. Liver and kidney damage has occurred. Pregnant women chronically exposed to toluene have shown teratogenic effects. Toluene is highly flammable.

R	1	NFPA
I	3	
S	2*	
K	3	
* Skin absorption		

HMIS	
H	2 - Chronic effects
F	3
R	0
PPE-Sec. 8	

Section 2. Ingredients and Occupational Exposure Limits

Toluene, < 100%; may contain a small amount of benzene (~ 1%), xylene, and nonaromatic hydrocarbons.

1991 OSHA PELs

8-hr TWA: 100 ppm (375 mg/m³)

15-min STEL: 150 ppm (560 mg/m³)

1990 IDLH Level

2000 ppm

1990 NIOSH RELs

TWA: 100 ppm (375 mg/m³)

STEL: 150 ppm (560 mg/m³)

1992-93 ACGIH TLV (Skin)

TWA: 50 ppm (188 mg/m³)

1990 DFG (Germany) MAK*

TWA: 100 ppm (380 mg/m³)

Half-life: 2 hr to end of shift

Category II: Substances with systemic effects

Peak Exposure Limit: 500 ppm, 30 min

average value, 2/shift

1985-86 Toxicity Data†

Man, inhalation, TC_{LD}: 100 ppm caused hallucinations, and changes in motor activity and changes in psychophysiological tests.

Human, oral, LD₅₀: 50 mg/kg; toxic effects not yet reviewed

Human, eye: 300 ppm caused irritation.

Rat, oral, LD₅₀: 5000 mg/kg

Rat, liver: 30 µmol/L caused DNA damage.

* Available information suggests damage to the developing fetus is probable.

† See NIOSH, RTECS (X5250000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 232 °F (110.6 °C)

Melting Point: -139 °F (-95 °C)

Molecular Weight: 92.15

Density: 0.866 at 68 °F (20/4 °C)

Surface Tension: 29 dyne/cm at 68 °F (20 °C)

Viscosity: 0.59 cP at 68 °F (20 °C)

Refraction Index: 1.4967 at 20 °C/D

Water Solubility: Very slightly soluble, 0.6 mg/L at 68 °F (20 °C)

Other Solubilities: Soluble in acetone, alcohol, ether, benzene, chloroform, glacial acetic acid, petroleum ether, and carbon disulfide.

Vapor Pressure: 22 mm Hg at 68 °F (20 °C); 36.7 mm Hg at 86 °F (30 °C)

Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.0797 lb/ft³ or 1.2755 kg/m³

Odor Threshold (range of all referenced values): 0.021 to 69 ppm

Appearance and Odor: Colorless liquid with a sickly sweet odor.

Section 4. Fire and Explosion Data

Flash Point: 40 °F (4.4 °C) CC

Autoignition Temperature: 896 °F (480 °C)

LEL: 1.27% v/v

UEL: 7.0% v/v

Extinguishing Media: Toluene is a Class 1B flammable liquid. To fight fire, use dry chemical carbon dioxide, or 'alcohol-resistant' foam. Water spray may be ineffective as toluene floats on water and may actually spread fire. **Unusual Fire or Explosion Hazards:** Concentrated vapors are heavier than air and may travel to an ignition source and flash back. Container may explode in heat of fire. Toluene's burning rate = 5.7 mm/min and its flame speed = 37 cm/sec. Vapor poses an explosion hazard indoors, outdoors, and in sewers. May accumulate static electricity. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire because a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Toluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can't occur. **Chemical Incompatibilities:** Strong oxidizers, concentrated nitric acid, nitric acid + sulfuric acid, dinitrogen tetroxide, silver perchlorate, bromine trifluoride, tetranitromethane, and 1,3-dichloro-5,5-dimethyl-2,4-imidazolidinone. **Conditions to Avoid:** Contact with heat, ignition sources, or incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of toluene can produce carbon dioxide, and acrid, irritating smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC⁽¹⁶⁴⁾ NTP⁽¹⁶⁹⁾ and OSHA⁽¹⁶⁴⁾ do not list toluene as a carcinogen. **Summary of Risks:** Toluene is irritating to the eyes, nose, and respiratory tract. Inhalation of high concentrations produces a narcotic effect sometimes leading to coma as well as liver and kidney damage. 93% of inhaled toluene is retained in the body of which 80% is metabolized to benzoic acid, then to hippuric acid and excreted in urine. The remainder is metabolized to *o*-cresol and excreted or exhaled unchanged. Toluene metabolism is inhibited by alcohol ingestion and is synergistic with benzene, asphalt fumes, or chlorinated hydrocarbons (i.e. perchloroethylene). Toluene is readily absorbed through the skin at 14 to 23 mg/cm²/hr. Toluene is absorbed quicker during exercise than at rest and appears to be retained longer in obese versus thin victims; presumably due to its lipid solubility. There is inconsistent data on toluene's ability to damage bone marrow; chronic poisoning has resulted in anemia and leucopenia with biopsy showing bone marrow hypo-plasia. These reports are few and some authorities argue that the effects may have been due to benzene contaminants. Chronic inhalation during pregnancy has been associated with teratogenic effects on the fetus including microcephaly, CNS dysfunction, attentional deficits, developmental delay + language impairment, growth retardation, and physical defects including a small midface, short palpebral fissures, with deep-set eyes, low-set ears, flat nasal bridge with a small nose, micrognathia, and blunt fingertips. There is some evidence that toluene causes an autoimmune illness in which the body produces antibodies that cause inflammation of its own kidney.

-Continue on next page

Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism and CNS, kidney, skin, or liver disease. **Target Organs:** CNS, liver, kidney, skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Acute Effects:** Vapor inhalation causes respiratory tract irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, watering eyes, nervousness, insomnia, parasthesia, and vertigo progressing to narcotic coma. Death may result from cardiac arrest due to ventricular fibrillation with catecholamines loss. Liquid splashed in the eye causes conjunctival irritation, transient corneal damage and possible burns. Prolonged skin contact leads to drying and fissured dermatitis. Ingestion causes GI tract irritation and symptoms associated with inhalation. **Chronic Effects:** Symptoms include mucous membrane irritation, headache, vertigo, nausea, appetite loss and alcohol intolerance. Repeated heavy exposure may result in encephalopathies (cerebellar ataxia and cognitive dysfunction), liver enlargement, and kidney dystrophy (wasting away). Symptoms usually appear at workdays end, worsen at weeks end and decrease or disappear over the weekend.

FIRST AID **Eyes:** Do not allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** Quickly remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. Do not induce vomiting because of danger of aspiration into the lungs. Gastric lavage may be indicated if large amounts are swallowed; potential toxicity needs to be weighed against aspiration risk when deciding for or against gastric lavage. **Note to Physicians:** Monitor cardiac function. If indicated, use epinephrine and other catecholamines carefully, because of the possibility of a lowered myocardial threshold to the arrhythmogenic effects of such substances. Obtain CBC, electrolytes, and urinalysis. Monitor arterial blood gases. If toluene has > 0.02% (200 ppm) benzene, evaluate for potential benzene toxicity. BEI: hippuric acid in urine, sample at shift end (2.5 g/g creatinine); Toluene in venous blood, sample at shift end (1.0 mg/L).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel protect against inhalation and skin/eye contact. Use water spray to cool and disperse vapors but it may not prevent ignition in closed spaces. Cellosolve, hycar absorbent materials, and fluorocarbon water can also be used for vapor suppression/containment. Take up small spill with earth, sand, vermiculite, or other absorbent, noncombustible material. Dike far ahead of large spills for later reclamation or disposal. For water spills, (10 ppm or greater) apply activated carbon at 10X the spilled amount and remove trapped material with suction hoses or use mechanical dredges/lifts to remove immobilized masses of pollutants and precipitates. Toluene can undergo fluidized bed incineration at 842 to 1796 °F (450 to 980 °C), rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), or liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C). Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue gill, LC₅₀ = 17 mg/L/24 hr; shrimp (*Crangonfraxis coron*), LC₅₀ = 4.3 ppm/96 hr; fathead minnow (*Pimephales promelas*), LC₅₀ = 36.2 mg/L/96 hr. **Environmental Degradation:** If released to land, toluene evaporates and undergoes microbial degradation. In water, toluene volatilizes and biodegrades with a half-life of days to several weeks. In air, toluene degrades by reaction with photochemically produced hydroxyl radicals. **Disposal:** Treat contaminated water by gravity separation of solids, followed by skimming of surface. Pass through dual media filtration and carbon absorption units (carbon ratio 1 kg to 10 kg soluble material). Return waste water from backwash to gravity separator. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U220

SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)

[* per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307 (a)]

Listed as a SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses with shatter-resistant glass and side-shields or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 100 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 200 ppm, use any SAR operated in continuous-flow mode, any SAR or SCBA with a full facepiece, or any air-purifying respirator with a full facepiece having a chin-style, front or back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning!** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol with a breakthrough time of > 8 hr, Teflon and Viton are recommended as suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰³⁾ **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove toluene from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Outside or detached storage is preferred. If stored inside, use a standard flammable liquids warehouse, room, or cabinet. To prevent static sparks, electrically ground and bond all equipment used with toluene. Do not use open lights in toluene areas. Install Class I, Group D electrical equipment. Check that toluene is free of or contains < 1% benzene before use. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Adopt controls for confined spaces (29 CFR 1910.146) if entering areas of unknown toluene levels (holes, wells, storage tanks). Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, liver, kidney, and skin. Include hemocytometric and thrombocyte count in cases where benzene is a contaminant of toluene. Monitor air at regular intervals to ensure effective ventilation.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Toluene

DOT Hazard Class: 3

ID No.: UN1294

DOT Packing Group: II

DOT Label: Flammable Liquid

Special Provisions (172.102): T1

Packaging Authorizations

a) Exceptions: 150

b) Non-bulk Packaging: 202

c) Bulk Packaging: 242

Quantity Limitations

a) Passenger Aircraft or Railcar: 5L

b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements

Vessel Stowage: B

Other: --

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 140, 148, 153, 159, 163, 164, 167, 169, 171, 174, 175, 176, 180.

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**Section 1. Material Identification**

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Ethylbenzene (C₈H₈) Description: Derived by heating benzene and ethylene in presence of aluminum chloride with subsequent distillation, by fractionation directly from the mixed xylene stream in petroleum refining, or dehydrogenation of naphthenes. Used as a solvent, an antiknock agent in gasoline; and as an intermediate in production of synthetic rubber, styrene, cellulose acetate, diethylbenzene, acetophenone, ethyl anthraquinone, propyl oxide, and α -methylbenzyl alcohol. Other Designations: CAS No. 100-41-4, ethylbenzol, EB, phenylethane, NCI-C56393.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*⁽⁷³⁾ for a suppliers list.

R 1	NFPA
I 3	3
S 2*	2
K 4	0
* Skin absorption	
HMIS	
H 2+	
F 3	
R 0	
PPE - Sec. 1	
† Chronic effects	

Cautions: Ethylbenzene is a skin and mucous membrane irritant considered the most irritating of the benzene series. Inhalation causes acute and chronic central nervous system (CNS) effects. It is highly flammable and forms explosive mixtures with air.

Section 2. Ingredients and Occupational Exposure Limits

Ethylbenzene, ca >99.0%. Impurities include ~ 0.1% *meta* & *para* xylene, ~ 0.1% cumene, and ~ 0.1% toluene.

1991 OSHA PELs

8-hr TWA: 100 ppm (435 mg/m³)
15-min STEL: 125 ppm (545 mg/m³)
Action Level: 50 ppm (217 mg/m³)

1990 IDLH Level

2000 ppm

1990 NIOSH REL

TWA: 100 ppm (435 mg/m³)
STEL: 125 ppm (545 mg/m³)

1992-93 ACGIH TLVs

TWA: 100 ppm (434 mg/m³)
STEL: 125 ppm (545 mg/m³)

1990 DFG (Germany) MAK

TWA: 100 ppm (440 mg/m³)
Category 1: local irritants
Peak Exposure Limit: 200 ppm, 5 min
momentary value, max of 8/shift
Danger of cutaneous absorption

1985-86 Toxicity Data*

Human, inhalation, TC_{Lo}: 100 ppm/8 hr caused eye effects, sleep, and respiratory changes.
Human, lymphocyte: 1 mmol/L induced sister chromatid exchange.
Rat, oral, LD₅₀: 3500 mg/kg; toxic effects not yet reviewed
Rat (female), inhalation, TC_{Lo}: 1000 ppm/7 hr/day, 5 days/wk, for 3 wk prior to mating and daily for 19 days of gestation produced pups with high incidence of extra ribs.⁽¹⁷⁹⁾

* See NIOSH, RTECS (DA0700000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 277 °F (136 °C)

Melting Point: -139 °F (-95 °C)

Surface Tension: 31.5 dyne/cm

Ionization Potential: 8.76 eV

Viscosity: 0.64 cP at 77 °F (25 °C)

Refraction Index: 1.4959 at 68 °F (20 °C)

Relative Evaporation Rate (ether = 1): 0.0106

Bulk Density: 7.21 lb/Gal at 77 °F (25 °C)

Critical Temperature: 651 °F (343.9 °C)

Critical Pressure: 35.6 atm

Molecular Weight: 106.16

Density: 0.863 at 77 °F (25 °C)

Water Solubility: Slightly, 14 mg/100 mL at 59 °F (15 °C)

Other Solubilities: Miscible in alcohol, ether; soluble in carbon tetrachloride, benzene, sulfur dioxide, and many organic solvents; insoluble in ammonia

Odor Threshold: 2.3 ppm

Vapor Pressure: 7.1 mm Hg at 68 °F (20 °C); 10 mmHg at 78.62 °F (25.9 °C); 100 mm Hg 165.38 °F (74.1 °C)

Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.0768 lb/ft³ or 1.2298 kg/m³

Appearance and Odor: Colorless, flammable liquid with a pungent odor.

Section 4. Fire and Explosion Data

Flash Point: 64 °F (18 °C) CC

Autoignition Temperature: 810 °F (432 °C)

LEL: 1.0% v/v

UEL: 6.7% v/v

Extinguishing Media: Class 1B Flammable liquid. For small fires, use dry chemical, carbon dioxide, or 'alcohol-resistant' foam. For large fires, use fog or 'alcohol-resistant' foam. Use water only if other agents are unavailable; EB floats on water and may travel to an ignition source and spread fire. Unusual Fire or Explosion Hazards: Burning rate = 5.8 mm/min. Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. EB poses a vapor explosion hazard indoors, outdoors, and in sewers. Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Cool container sides with water until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Withdraw immediately if you hear rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Ethylbenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Reacts vigorously with oxidizers.

Conditions to Avoid: Exposure to heat and oxidizers.

Hazardous Products of Decomposition: Thermal oxidative decomposition of EB can produce acid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,⁽¹⁶⁴⁾ NTP,⁽¹⁶⁹⁾ and OSHA⁽¹⁶⁴⁾ do not list EB as a carcinogen. Summary of Risks: Occupational exposure to EB alone is rare since it is usually present together with other solvents. EB is irritating to the eyes, skin, and respiratory tract. Vapor inhalation produces varying degrees of CNS effects depending on concentration. The liquid is absorbed through the skin but vapors are not. 56 to 64% of inhaled ethylbenzene is retained and metabolized. Urinary metabolites following exposure to 23 to 85 ppm for 8 hr are mandelic acid (64%), phenylglyoxylic acid (25%), and methylphenylcarbinol/1-phenyl ethanol (5%). Concurrent exposure to xylene and ethylbenzene causes slower excretion of EB metabolites. Based on the rat LD₅₀, one manufacturer gives 3 to 4 oz. as the lethal dose for a 100 lb person.

Continue on next page

Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Skin and CNS diseases and impaired pulmonary function (especially obstructive airway disease). **Target Organs:** Eyes, respiratory system, skin, CNS, blood. **Primary Entry Routes:** Inhalation, skin and eye contact. **Acute Effects:** Vapor inhalation of 200 ppm caused transient eye irritation; 1000 ppm caused eye irritation with profuse watering (tolerance developed rapidly); 2000 ppm caused severe and immediate eye irritation and watering, nasal irritation, chest constriction, and vertigo; 5000 ppm was intolerable and caused eye and nose irritation. Inhalation of high concentrations may cause narcosis, cramps, and death due to respiratory paralysis. Skin exposed to pure ethylbenzene for 10 to 15 min absorbed 22 to 33 mg/cm²/hr. Immersion of hand in solutions of 112 & 156 mg/L for 1 hr absorbed 118 & 215.7 µg/cm²/hr, respectively. **Chronic Effects:** Repeated skin contact may cause dryness, scaling, and fissuring. Workers chronically exposed to > 100 ppm complained of fatigue, sleepiness, headache, and mild irritation of the eyes and respiratory tract. Repeated vapor inhalation may result in blood disorders, particularly leukopenia (abnormally low level of white blood cells) and lymphocytosis.

FIRST AID

Eyes: Do not allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** Quickly remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that conscious and alert person drink 1 to 2 glasses of water to dilute. Do not induce vomiting! Aspiration of even a small amount of EB in vomitus can cause severe damage since its low viscosity and surface tension will cause it to spread over a large area of the lung tissue.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: BEI = mandelic acid in urine (1.5 g/g of creatinine), sample at end of shift at workweeks end. Since this test is not specific, test for EB in expired air for confirmation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate and ventilate area, deny entry and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container. Dike far ahead of large spill for later reclamation or disposal. Report any release >1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, EB partially evaporates into the atmosphere, with a half-life of hrs to wks, and some leaches into groundwater, especially in soil with low organic carbon content. Biodegradation occurs with a half-life of 2 days. Some EB may absorb to sediment or bioconcentrate in fish. Evidence points to slow biodegradation in groundwater. In air, it reacts with photochemically produced hydroxyl radicals with a half-life of hrs to 2 days. Additional amounts may be removed by rain. **Ecotoxicity Values:** Shrimp (*Mydopsis bahia*), LC₅₀ = 87.6 mg/L/96 hr; sheepshead minnow (*Cyprinodon variegatus*) LC₅₀ = 275 mg/L/96 hr; fathead minnow (*Pimephales promelas*) LC₅₀ = 42.3 mg/L/96 hr in hard water & 48.5 mg/L/96 hr in softwater. **Disposal:** A candidate for rotary kiln incineration at 1508 to 2912°F (820 to 1600°C), liquid injection incineration at 1202 to 2912°F (650 to 1600°C), and fluidized bed incineration at 842 to 1796°F (450 to 980°C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.21): No. D001

Listed as a SARA Toxic Chemical (40 CFR 372.65)

SARA Extremely Hazardous Substance (40 CFR 355). TPQ: Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311 (b)(4) & CWA, Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use a powered air-purifying respirator with an appropriate organic vapor cartridge, a supplied-air respirator (SAR), SCBA, or chemical cartridge respirator with appropriate organic vapor cartridge. For < 2000 ppm, use a SAR or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning!** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton or polyvinylchloride to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰³⁾ **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from ignition sources and oxidizers. Outside or detached storage is preferred. If inside, store in a standard flammable liquids cabinet. Containers should have flame-arrester or pressure-vacuum venting. To prevent static sparks, electrically ground and bond all equipment used with ethylbenzene. Install Class 1, Group D electrical equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain levels as low as possible. Purge and ventilate reaction vessels before workers are allowed to enter for maintenance or cleanup. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, skin, blood, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Ethylbenzene

DOT Hazard Class: 3

ID No.: UN1175

DOT Packing Group: II

DOT Label: Flammable liquid

Special Provisions (172.102): T1

Packaging Authorizations

a) Exceptions: 173.150

b) Non-bulk Packaging: 173.202

c) Bulk Packaging: 173.242

Quantity Limitations

a) Passenger Aircraft or Railcar: 5L

b) Cargo Aircraft Only: 60 L

Vessel Stowage Requirements

a) Vessel Stowage: B

b) Other: —

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 153, 159, 162, 163, 164, 167, 168, 171, 176, 179

Prepared by: M Gannon, BA; Industrial Hygiene Review: D Wilson, CIH; Medical Review: W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 318
Xylene (Mixed Isomers)

Issued: 11/80 Revision: E, 9/92

Section 1. Material Identification

Xylene (Mixed Isomers) (C₈H₁₀) Description: The commercial product is a blend of the three isomers [*ortho*-(*o*-), *meta*-(*m*-), *para*-(*p*-)] with the largest proportion being *m*-xylene. Xylene is obtained from coal tar, toluene by transalkylation, and pseudocumene. Used in the manufacture of dyes, resins, paints, varnishes, and other organics; as a general solvent for adhesives, a cleaning agent in microscope technique; as a solvent for Canada balsam microscopy; as a fuel component; in aviation gasoline, protective coatings, sterilizing catgut, hydrogen peroxide, perfumes, insect repellants, pharmaceuticals, and the leather industry; in the production of phthalic anhydride, isophthalic, and terephthalic acids and their dimethyl esters which are used in the manufacture of polyester fibers; and as an indirect food additive as a component of adhesives. Around the home, xylene is found as vehicles in paints, paint removers, degreasing cleaners, lacquers, glues and cements and as solvent/vehicles for pesticides.

Other Designations: CAS No. 1330-20-7 [95-47-6; 108-38-3; 106-42-3 (*o*-, *m*-, *p*-isomers)], dimethylbenzene, methyltoluene, NCI-C55232, Violet 3, xylol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*⁽⁷³⁾ for a suppliers list.

Cautions: Xylene is an eye, skin, and mucous membrane irritant and may be narcotic in high concentrations. It is a dangerous fire hazard.

R 1	NFPA
I 2	
S 2	
K 3	
	HMIS
	H 2+
	F 3
	R 0
	PPE †
	† Chronic Effects
	‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Xylene (mixed isomers): the commercial product generally contains ~ 40% *m*-xylene; 20% each of *o*-xylene, *p*-xylene, and ethylbenzene; and small quantities of toluene. Unpurified xylene may contain pseudocumene.

1991 OSHA PELs

8-hr TWA: 100 ppm (435 mg/m³)

15-min STEL: 150 ppm (655 mg/m³)

1990 IDLH Level

1000 ppm

1990 NIOSH RELs

TWA: 100 ppm (435 mg/m³)

STEL: 150 ppm (655 mg/m³)

1992-93 ACGIH TLVs

TWA: 100 ppm (434 mg/m³)

STEL: 150 ppm (651 mg/m³)

BEI (Biological Exposure Index): Methylhippuric acids in urine at end of shift: 1.5 g/g creatinine

1990 DFG (Germany) MAK

TWA: 100 ppm (440 mg/m³)

Category II: Substances with systemic effects

Half-life: < 2 hr

Peak Exposure: 200 ppm, 30 min, average value, 4 peaks per shift

1985-86 Toxicity Data*

Human, inhalation, TC_{Lo}: 200 ppm produced olfaction effects, conjunctiva irritation, and other changes involving the lungs, thorax, or respiration.

Man, inhalation, LC_{Lo}: 10000 ppm/6 hr; toxic effects not yet reviewed.

Human, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted.

Rat, oral, LD₅₀: 4300 mg/kg; toxic effect not yet reviewed.

Rat, inhalation, LC₅₀: 5000 ppm/4 hr; toxic effects not yet reviewed.

* See NIOSH, RTECS (XE2100000), for additional toxicity data.

Section 3. Physical Data

Boiling Point Range: 279 to 284 °F (137 to 140 °C)*

Boiling Point: *ortho*: 291 °F (144 °C); *meta*: 281.8 °F (138.8 °C);

para: 281.3 °F (138.5 °C)

Freezing Point/Melting Point: *ortho*: -13 °F (-25 °C);

meta: -53.3 °F (-47.4 °C); *para*: 55 to 57 °F (13 to 14 °C)

Vapor Pressure: 6.72 mm Hg at 70 °F (21 °C)

Saturated Vapor Density (Air = 1.2 kg/m³): 1.23 kg/m³, 0.077 lbs/ft³

Appearance and Odor: Clear, sweet-smelling liquid.

* Materials with wider and narrower boiling ranges are commercially available.

Molecular Weight: 106.16

Specific Gravity: 0.864 at 20 °C/4 °C

Water Solubility: Practically insoluble

Other Solubilities: Miscible with absolute alcohol, ether, and many other organic liquids.

Octanol/Water Partition Coefficient: logKow = 3.12-3.20

Odor Threshold: 1 ppm

Viscosity: <32.6 SUS

Section 4. Fire and Explosion Data

Flash Point: 63 to 77 °F (17 to 25 °C) CC **Autoignition Temperature:** 982 °F (527 °C) (*m*-) **LEL:** 1.1 (*m*-, *p*-); 0.9 (*o*-) **UEL:** 7.0 (*m*-, *p*-); 6.7 (*o*-)

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO₂), water spray or regular foam. For large fires, use water spray, fog or regular foam. Water may be ineffective. Use water spray to cool fire-exposed containers. **Unusual Fire or Explosion Hazards:** Xylene vapors or liquid (which floats on water) may travel to an ignition source and flash back. The heat of fire may cause containers to explode and/or produce irritating or poisonous decomposition products. Xylene may present a vapor explosion hazard indoors, outdoors, or in sewers. Accumulated static electricity may occur from vapor or liquid flow sufficient to cause ignition. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide limited protection. If feasible and without risk, move containers from fire area. Otherwise, cool fire-exposed containers until well after fire is extinguished. Stay clear of tank ends. Use unmanned hose holder or monitor nozzles for massive cargo fires. If impossible, withdraw from area and let fire burn. Withdraw immediately in case of any tank discoloration or rising sound from venting safety device. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Xylene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Xylene is easily chlorinated, sulfonated, or nitrated. **Chemical Incompatibilities:** Incompatibilities include strong acids and oxidizers and 1,3-dichloro-5,5-dimethyl-2,4-imidazolidindione (dichlorohydrantoin). Xylene attacks some forms of plastics, rubber, and coatings. **Conditions to Avoid:** Avoid heat and ignition sources and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of xylene can produce carbon dioxide, carbon monoxide, and various hydrocarbon products.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,⁽¹⁶⁴⁾ NTP,⁽¹⁶⁹⁾ and OSHA⁽¹⁶⁴⁾ do not list xylene as a carcinogen. **Summary of Risks:** Xylene is an eye, mucous membrane, and respiratory tract irritant. Irritation starts at 200 ppm; severe breathing difficulties which may be delayed in onset can occur at high concentrations. It is a central nervous system (CNS) depressant and at high concentrations can cause coma. Kidney and liver damage can occur with xylene exposure. With prolonged or repeated cutaneous exposure, xylene produces a defatting dermatitis. Chronic toxicity is not well defined, but it is less toxic than benzene. Prior to the 1950s, benzene was often found as a contaminant of xylene and the effects attributed to xylene such as blood dyscrasias are questionable. Since the late 1950s, xylenes have been virtually benzene-free and blood dyscrasias have not been associated with xylenes. Chronic exposure to high concentrations of xylene in animal studies have demonstrated milk reversible decrease in red and white cell counts as well as increases in platelet counts.

Continue on next page

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Section 6. Health Hazard Data, continued

irregularity was reported in association with workplace exposure to xylene perhaps due to effects on liver metabolism. Xylene crosses the human placenta, but does not appear to be teratogenic under conditions tested to date. **Medical Conditions Aggravated by Long-Term Exposure:** CNS, respiratory, eye, skin, gastrointestinal (GI), liver and kidney disorders. **Target Organs:** CNS, eyes, GI tract, liver, kidneys, and skin. **Primary Entry Routes:** Inhalation, skin absorption (slight), eye contact, ingestion. **Acute Effects:** Inhalation of high xylene concentrations may cause dizziness; nausea, vomiting, and abdominal pain; eye, nose, and throat irritation; respiratory tract irritation leading to pulmonary edema (fluid in lung); drowsiness; and unconsciousness. Direct eye contact can result in conjunctivitis and corneal burns. Ingestion may cause a burning sensation in the oropharynx and stomach and transient CNS depression. **Chronic Effects:** Repeated or prolonged skin contact may cause drying and defatting of the skin leading to dermatitis. Repeated eye exposure to high vapor concentrations may cause reversible eye damage, peripheral and central neuropathy, and liver damage. Other symptoms of chronic exposure include headache, fatigue, irritability, chronic bronchitis, and GI disturbances such as nausea, loss of appetite, and gas.

FIRST AID Emergency personnel should protect against exposure. **Eyes:** Do not allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** Quickly remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing as it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. Monitor exposed person for respiratory distress. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, *do not induce vomiting!* If spontaneous vomiting should occur, keep exposed person's head below the hips to prevent aspiration (breathing liquid xylene into the lungs). *Aspiration of a few millimeters of xylene can cause chemical pneumonitis, pulmonary edema, and hemorrhage.* Note to Physicians: Hippuric acid or the ether glucuronide of ortho-toluic acid may be useful in diagnosis of meta-, para- and ortho-xylene exposure, respectively. Consider gastric lavage if a large quantity of xylene was ingested. Proceed gastric lavage with protection of the airway from aspiration; consider endotracheal intubation with inflated cuff.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and ventilate spill area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If feasible and without undue risk, stop leak. Use appropriate foam to blanket release and suppress vapors. Water spray may reduce vapor, but does not prevent ignition in closed spaces. For small spills, absorb on paper and evaporate in appropriate exhaust hood or absorb with sand or some non-combustible absorbent and place in containers for later disposal. For large spills dike far ahead of liquid to contain. Do not allow xylene to enter a confined space such as sewers or drains. On land, dike to contain or divert to impermeable holding area. Apply water spray to control flammable vapor and remove material with pumps or vacuum equipment. On water, contain material with natural barriers, booms, or weirs; apply universal gelling agent; and use suction hoses to remove spilled material. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** Little bioconcentration is expected. Biological oxygen demand 5 (after 5 days at 20 °C): 0.64 (no stated isomer). Ecotoxicity values: LD₅₀, Goldfish, 13 mg/L/24 hr, conditions of bioassay not specified, no specific isomer. **Environmental Degradation:** In the atmosphere, xylenes degrade by reacting with photochemically produced hydroxyl radicals with a half-life ranging from 1-1.7 hr. in the summer to 10-18 hr in winter or a typical loss of 67-86% per day. Xylenes are resistant to hydrolysis. **Soil Absorption/Mobility:** Xylenes have low to moderate adsorption to soil and when spilled on land, will volatilize and leach into groundwater. **Disposal:** As a hydrocarbon, xylene is a good candidate for controlled incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U239, F003 (spent solvent)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act,

Sec. 311(b)(4); per RCRA, Sec. 3001]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations >1000 ppm, use any chemical cartridge respirator with organic vapor cartridges; any powered, air-purifying respirator with organic vapor cartridges; any supplied-air respirator; or any self-contained breathing apparatus. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning!** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. With breakthrough times > 8 hr, consider polyvinyl alcohol and fluorocarbon rubber (Viton) as materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰³⁾ **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in clearly labelled, tightly closed, containers in a cool, well-ventilated place, away from strong oxidizing materials and heat and ignition sources. During transferring operations, electrically ground and bond metal containers. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use hermetically sealed equipment, transfer xylene in enclosed systems, avoid processes associated with open evaporating surfaces, and provide sources of gas release with enclosures and local exhaust ventilation. Use Class I, Group D electrical equipment. **Administrative Controls:** Establish air and biological monitoring programs and evaluate regularly. Consider preplacement and periodic medical examinations including a complete blood count, a routine urinalysis, and liver function tests. Consider hematologic studies if there is any significant contamination of the solvent with benzene. If feasible, consider the replacement of xylene by less toxic solvents such as petrol (motor fuel) or white spirit. Before carrying out maintenance and repair work, steam and flush all equipment to remove any xylene residues.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Xylenes

DOT Hazard Class: 3

ID No.: UN1307

DOT Packing Group: II

DOT Label: Flammable Liquid

Special Provisions (172.102): T1

Packaging Authorizations

a) Exceptions: 173.150

b) Nonbulk Packaging: 173.202

c) Bulk Packaging: 173.242

Quantity Limitations

a) Passenger, Aircraft, or Railcar: 5L

b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements

a) Vessel Stowage: B

b) Other: —

MSDS Collection References: 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 171, 174, 176, 180.

Prepared by: MJ Wurdh, BS; Industrial Hygiene Review: PA Roy, MPH, CIH; Medical Review: W Silverman, MD

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4/9/1

00003342

OHS/MDL Record Number : OHS14283

MATERIAL SAFETY DATA SHEET**SECTION 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION**

MDL Information Systems, Inc.
14600 Catalina Street
San Leandro CA 94577
1-800-635-0064 (Toll Free) or
1-510-895-1313

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000 in USA

RTECS Number : PC1400000
EU Number (EINICS) : 200-659-6

SUBSTANCE: METHANOL REAGENT ACS

TRADE NAME/SYNONYM(S): METHANOL; WOOD ALCOHOL; METHYL HYDROXIDE; CARBINOL;
MONOHYDROXYMETHANE; WOOD SPIRIT; WOOD NAPHTHA; METHYLOL; COLONIAL SPIRIT
; COLUMBIAN SPIRIT; PYROXYLIC SPIRIT; CH4O; RCRA U154; UN 1230; STCC
4904230; OHS14283; RTECS PC1400000

CHEMICAL FAMILY: hydroxyls; aliphatic
CREATION DATE: 19890308 REVISED: 19970915

SECTION 2 - COMPOSITION, INFORMATION ON INGREDIENTS

1) Component Substance: METHYL ALCOHOL
Component Percent: >60.0 %
CAS Registry Number: 67-56-1

SECTION 3 - HAZARDS IDENTIFICATION

NFPA Ratings (scale 0-4): Health=2 Fire=3 Reactivity=0
EU CLASSIFICATION: F Highly Flammable; T Toxic; R 11-23/25; EC
Classification may be inconsistent with independently-researched data.

EMERGENCY OVERVIEW:

COLOR: colorless

PHYSICAL FORM: liquid

ODOR: distinct odor

MAJOR HEALTH HAZARDS: skin irritation, eye irritation, central nervous
system depression

PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire.

POTENTIAL HEALTH EFFECTS**INHALATION:**SHORT TERM EXPOSURE: same as effects reported in short term ingestion,
irritation, ringing in the ears, digestive disorders, symptoms of
drunkenness, visual disturbances, nerve damage.LONG TERM EXPOSURE: same as effects reported in short term ingestion,
headache.**SKIN CONTACT:**SHORT TERM EXPOSURE: same as effects reported in short term ingestion,
irritation, symptoms of drunkenness, nerve damage.

LONG TERM EXPOSURE: same as effects reported in short term exposure.

EYE CONTACT:

SHORT TERM EXPOSURE: irritation, eye damage.

LONG TERM EXPOSURE: same as effects reported in short term exposure.

INGESTION:

SHORT TERM EXPOSURE: nausea, vomiting, diarrhea, difficulty breathing, irregular heartbeat, headache, drowsiness, symptoms of drunkenness, disorientation, hearing loss, blindness, bluish skin color, lung congestion, nerve damage, convulsions, coma.

LONG TERM EXPOSURE: same as effects reported in short term ingestion.

CARCINOGEN STATUS:

OSHA: N

NTP: N

IARC: N

SECTION 4 - FIRST AID MEASURES

INHALATION:

Remove from exposure immediately. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Get medical attention.

SKIN CONTACT:

Remove contaminated clothing, jewelry, and shoes immediately. Wash with soap or mild detergent and large amounts of water until no evidence of chemical remains (at least 15-20 minutes). Get medical attention, if needed.

EYE CONTACT:

Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains. Get medical attention immediately.

INGESTION:

Contact local poison control center or physician immediately. Never make an unconscious person vomit or drink fluids. When vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.

NOTE TO PHYSICIAN:

For ingestion, consider gastric lavage.

ANTIDOTE:

ethanol, oral; calcium gluconate/glucose, intravenous. 4-methylpyrazole, oral, intravenous.

SECTION 5 - FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:

Severe fire hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive.

EXTINGUISHING MEDIA:

alcohol resistant foam, carbon dioxide, regular dry chemical, water
Large fires: Use alcohol-resistant foam or flood with fine water spray.
FIRE FIGHTING: Move container from fire area if it can be done without risk. Dike for later disposal. Do not scatter spilled material with high-pressure water streams. Cool containers with waterspray until well after the fire is out. Stay away from the ends of tanks. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck, evacuation radius: 800 meters (1/2 mile).

FLASH POINT: 52 F (11 C) (CC)

LOWER EXPLOSIVE LIMIT: 6.0%

UPPER EXPLOSIVE LIMIT: 36.0%

AUTOIGNITION: 725 F (385 C)

FLAMMABILITY CLASS (OSHA): IB

SECTION 6 - ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:

Avoid heat, flames, sparks and other sources of ignition. Do not touch

spilled material. Stop leak if possible without personal risk. Reduce vapors with water spray. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Large spills: Dike for later disposal. Remove sources of ignition. Keep unnecessary people away, isolate hazard area and deny entry. Reportable Quantity (RQ): 5000 pounds. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SOIL SPILL:

Dig holding area such as lagoon, pond or pit for containment. Dike for later disposal.

AIR SPILL:

Reduce vapors with water spray.

WATER SPILL:

Cover with absorbent sheets, spill-control pads or pillows. Remove trapped material with suction hoses.

Allow spilled material to aerate.

SECTION 7 - HANDLING AND STORAGE

Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Keep separated from incompatible substances.

SECTION 8 - EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:

METHANOL REAGENT ACS:

METHYL ALCOHOL (METHANOL):

200 ppm (262 mg/m3) OSHA TWA (skin)
250 ppm (328 mg/m3) OSHA STEL (vacated by 58 FR 35338, June 30, 1993)
200 ppm (262 mg/m3) ACGIH TWA (skin)
250 ppm (328 mg/m3) ACGIH STEL
200 ppm (262 mg/m3) NIOSH recommended TWA (skin)
250 ppm (328 mg/m3) NIOSH recommended STEL
260 mg/m3 (200 ml/m3) DFG MAK 4 times/shift
MEASUREMENT METHOD: Silica gel tube; Water; Gas chromatography with flame ionization detection; NIOSH III # 2000, Methanol

VENTILATION:

Provide local exhaust or process enclosure ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION:

Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING:

Wear appropriate chemical resistant clothing.

GLOVES:

Wear appropriate chemical resistant gloves.

RESPIRATOR:

The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.

2000 ppm Any supplied-air respirator.

5000 ppm Any supplied-air respirator.

6000 ppm Any supplied-air respirator with a full facepiece. Any self-contained breathing apparatus with a full facepiece. Any supplied-air respirator with a full facepiece.

Escape - Any appropriate escape-type, self-contained breathing apparatus.

For Unknown Concentrations or Immediately Dangerous to Life or Health - Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply. Any self-contained breathing apparatus with a full facepiece.

SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: PHYSICAL STATE: liquid

APPEARANCE: clear

COLOR: colorless

ODOR: distinct odor

MOLECULAR WEIGHT: 32.04

MOLECULAR FORMULA: C-H3-O-H

BOILING POINT: 149 F (65 C)

MELTING POINT: -137 F (-94 C)

SPECIFIC GRAVITY: 0.7914

pH: Not available

VISCOSITY: 0.59 cP @ 20 C

VAPOR PRESSURE: 97.25 mmHg @ 20 C

VAPOR DENSITY: 1.11

VOLATILITY: Not available

EVAPORATION RATE: 4.6 (butyl acetate=1)

ODOR THRESHHOLD: 100 ppm

WATER SOLUBILITY: soluble

SOLVENT SOLUBILITY: Soluble: alcohol, acetone, chloroform, ethanol, ether, benzene

SECTION 10 - STABILITY AND REACTIVITY

REACTIVITY:

Stable at normal temperatures and pressure.

CONDITIONS TO AVOID:

Avoid heat, flames, sparks and other sources of ignition. Minimize contact with material. Avoid inhalation of material or combustion by-products. Keep out of water supplies and sewers.

INCOMPATIBILITIES:

halo carbons, combustible materials, metals, oxidizing materials, halogens, metal carbide, bases, acids

METHYL ALCOHOL (METHANOL):

ACETYL BROMIDE: Violent reaction with formation of hydrogen bromide

ALKYLALUMINUM SOLUTIONS: Violent reaction

ALUMINUM: Corrodes

BARIUMPERCHLORATE: Distillation yields highly explosive alkyl perchlorate

BERYLLIUM HYDRIDE: Violent reaction, even at -196 C

BROMINE: Vigorously exothermic reaction

CALCIUM CARBIDE: Violent reaction

CHLORINE: Possible ignition and explosion hazard

CHLOROFORM AND SODIUM HYDROXIDE: Explosive reaction

CHROMIUM TRIOXIDE (CHROMIC ANHYDRIDE): Possible ignition

CYANURIC CHLORIDE: Violent reaction

DICHLOROMETHANE: Possible ignition and explosion

DIETHYL ZINC: Possible ignition and explosion

HYDROGEN PEROXIDE + WATER: Explosionhazard

IODINE + ETHANOL + MERCURIC OXIDE: Explosion hazard

LEAD: Corrodes

LEAD PERCHLORATE: Explosion hazard

MAGNESIUM: Violent reaction

MAGNESIUM (POWDERED): Mixtures are capable of detonation

METALS: Incompatible

NICKEL: Possible ignition in the presence of nickel catalyst

NITRIC ACID (CONCENTRATED): Mixtures of greater than25% acid may decompose violently

OXIDIZERS (STRONG): Fire and explosion hazard

PERCHLORIC ACID: Explosion hazard

PHOSPHOROUS TRIOXIDE: Possible violent reaction and ignition

PLASTICS, RUBBER, COATINGS: May be attacked

POTASSIUM: Possible dangerous reaction

POTASSIUM HYDROXIDE + CHLOROFORM: Exothermic reaction

POTASSIUM TERT-BUTOXIDE: Fire and explosion hazard

SODIUM + CHLOROFORM: Possible explosion

SODIUM HYPOCHLORITE: Explosion hazard

SODIUM METHOXIDE + CHLOROFORM: Violent reaction

SULFURIC ACID: Fire and explosion hazard

ZINC: Explosion hazard

HAZARDOUS DECOMPOSITION:

Thermal decomposition products: oxides of carbon

POLYMERIZATION:

Will not polymerize.

SECTION 11 - TOXICOLOGICAL INFORMATION

METHANOL REAGENT ACS:

IRRITATION DATA:

20 mg/24 hour(s) skin-rabbit moderate; 40 mg eyes-rabbit moderate; 100
mg/24 hour(s) eyes-rabbit moderate.

TOXICITY DATA:

6422 mg/kg oral-man LDLo; 3429 mg/kg oral-man TDLo; 428 mg/kg oral-human LDLo; 143 mg/kg oral-human LDLo; 4 gm/kg oral-woman TDLo; 86000 mg/m3 inhalation-human TCLo; 300 ppm inhalation-human TCLo; 868 mg/kg unreported-man LDLo; 5628 mg/kg oral-rat LD50; 64000 ppm/4 hour(s) inhalation-rat LC50; 7529 mg/kg intraperitoneal-rat LD50; 2131 mg/kg intravenous-rat LD50; 7300 mg/kg oral-mouse LD50; 50 gm/m3/2 hour(s) inhalation-mouse LCLo; 10765 mg/kg intraperitoneal-mouse LD50; 9800 mg/kg subcutaneous-mouse LD50; 4710 mg/kg intravenous-mouse LD50; 7500 mg/kg oral-dog LDLo; 7 gm/kg oral-monkey LD50; 1000 ppm inhalation-monkey LCLo; 393 mg/kg skin-monkey LDLo; 44 gm/m3/6 hour(s) inhalation-cat LCLo; 4641 mg/kg intravenous-cat LDLo; 14200 mg/kg oral-rabbit LD50; 15800 mg/kg skin-rabbit LD50; 1826 mg/kg intraperitoneal-rabbit LD50; 8907 mg/kg intravenous-rabbit LD50; 3556 mg/kg intraperitoneal-guinea pig LD50; 8555 mg/kg intraperitoneal-hamster LD50; 59 gm/kg parenteral-frog LDLo; 12 gm/kg/8 week(s) intermittent oral-rat TDLo; 7 ml/kg/7 day(s) intermittent oral-rat TDLo; 50 mg/m3/12 hour(s)-13 week(s) intermittent inhalation-rat TCLo; 2610 ppm/6 hour(s)-4 week(s) intermittent inhalation-rat TCLo; 3846 ug/kg/30 day(s) intermittent intraperitoneal-rat TDLo.

ACUTE TOXICITY LEVEL:

Slightly Toxic: dermal absorption, ingestion. Relatively Non-toxic: inhalation.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:

eye disorders, kidney disorders, skin disorders and allergies.

MUTAGENIC DATA:

DNA repair - Escherichia coli 20 mg/well; mutation in microorganisms - Saccharomyces cerevisiae 12 pph (-S9); sex chromosome loss and non disjunction - Aspergillus nidulans 56000 ppm; cytogenetic analysis - grasshopper parenteral 3000 ppm; DNA inhibition - human lymphocyte 300 mmol/L; DNA damage - rat oral 10 umol/kg; mutation in microorganisms - mouse lymphocyte 7900 mg/L (+S9); cytogenetic analysis - mouse oral 1 gm/kg; cytogenetic analysis - mouse intraperitoneal 75 mg/kg.

REPRODUCTIVE EFFECTS DATA:

7500 mg/kg oral-rat TDLo 17-19 day(s) pregnant female continuous; 35295 mg/kg oral-rat TDLo 1-15 day(s) pregnant female continuous; 35295 mg/kg oral-rat TDLo 1-15 day(s) pregnant female continuous; 20 gm/kg oral-rat TDLo 6-15 day(s) pregnant female continuous; 20000 ppm inhalation-rat TCLo/7 hour(s) 1-22 day(s) pregnant female continuous; 20000 ppm inhalation-rat TCLo/7 hour(s) 7-15 day(s) pregnant female continuous; 10000 ppm inhalation-rat TCLo/7 hour(s) 7-15 day(s) pregnant female continuous; 200 ppm oral-rat TDLo/20 hour(s) 78 week(s) male; 40 gm/kg oral-mouse TDLo 6-15 day(s) pregnant female continuous; 1500 ppm inhalation-mouse TCLo/6 hour(s) 7-9 day(s) pregnant female continuous; 5000 ppm inhalation-mouse TCLo/7 hour(s) 6-15 day(s) pregnant female continuous; 7500 ppm inhalation-mouse TCLo/7 hour(s) 6-15 day(s) pregnant female continuous; 2000 ppm inhalation-mouse TCLo/7 hour(s) 6-15 day(s) pregnant female continuous; 15000 ppm inhalation-mouse TCLo 7-9 day(s) pregnant female continuous; 5 gm/kg intraperitoneal-mouse TDLo 5 day(s) male.

ADDITIONAL DATA:

May cause blindness.

METHYL ALCOHOL:**IRRITATION DATA:**

20 mg/24 hour(s) skin-rabbit moderate; 40 mg eyes-rabbit moderate; 100 mg/24 hour(s) eyes-rabbit moderate.

TOXICITY DATA:

6422 mg/kg oral-man LDLo; 3429 mg/kg oral-man TDLo; 428 mg/kg oral-human LDLo; 143 mg/kg oral-human LDLo; 4 gm/kg oral-woman TDLo; 86000 mg/m3 inhalation-human TCLo; 300 ppm inhalation-human TCLo; 868 mg/kg unreported-man LDLo; 5628 mg/kg oral-rat LD50; 64000 ppm/4 hour(s) inhalation-rat LC50; 7529 mg/kg intraperitoneal-rat LD50; 2131 mg/kg intravenous-rat LD50; 7300 mg/kg oral-mouse LD50; 50 gm/m3/2 hour(s) inhalation-mouse LCLo; 10765 mg/kg intraperitoneal-mouse LD50; 9800 mg/kg subcutaneous-mouse LD50; 4710 mg/kg intravenous-mouse LD50; 7500 mg/kg oral-dog LDLo; 7 gm/kg oral-monkey LD50; 1000 ppm inhalation-monkey LCLo;

Skin absorption may occur and cause metabolic acidosis and effects on the eyes and central nervous system as detailed in acute ingestion.

CHRONIC EXPOSURE:

METHYL ALCOHOL (METHANOL): Repeated or prolonged contact with the liquid may cause defatting of the skin resulting in erythema, scaling, and eczematoid dermatitis. Chronic absorption may result in metabolic acidosis and effects as detailed in acute ingestion.

EYE CONTACT:

ACUTE EXPOSURE:

METHYL ALCOHOL (METHANOL): Vapors may cause irritation. High concentrations have been reported to cause violent inflammation of the conjunctiva and epithelial defects on the cornea. Mild irritation may occur with dilute solutions; the undiluted liquid has produced moderate corneal opacity and conjunctival redness in rabbits. Application of a drop of methanol in rabbit eyes caused a mild reversible reaction, graded 3 on a scale of 1-10 after 24 hours.

CHRONIC EXPOSURE:

METHYL ALCOHOL (METHANOL): Repeated or prolonged contact may cause conjunctivitis.

INGESTION:

ACUTE EXPOSURE:

METHYL ALCOHOL (METHANOL): May cause mild and transient inebriation and subsequent drowsiness followed by an asymptomatic period lasting 8-48 hours. Following the delay, coughing, dyspnea, headache, dullness, weakness, vertigo or dizziness, nausea, vomiting, occasional diarrhea, anorexia, violent pain in the back, abdomen, and extremities, restlessness, apathy or delirium, and rarely, excitement and mania may occur. Rapid, shallow respiration due to metabolic acidosis, cold and clammy skin, hypotension, cyanosis, opisthotonos, convulsions, mild tachycardia, cardiac depression, peripheral neuritis, cerebral and pulmonary edema, unconsciousness, and coma are possible. Effects on the eye may include optic neuritis, blurred or dimmed vision, dilated, unresponsive pupils, ptosis, eye pain, concentric constriction of visual fields, diplopia, change in color perception, photophobia, and optic nerve atrophy. Partial blindness or possibly delayed transient or permanent blindness may occur. Bilateral sensorineural deafness has been reported in a single case. Liver, kidney, heart, stomach, intestinal and pancreatic damage may also occur. Death may be due to respiratory failure or rarely from circulatory collapse. As little as 15 ml has caused blindness; the usual fatal dose is 60-240 ml. Prolonged asthenia and irreversible effects on the nervous system including difficulty in speech, motor dysfunction with rigidity, spasticity, and hypokinesia have been reported.

CHRONIC EXPOSURE:

METHYL ALCOHOL (METHANOL): Repeated ingestion may cause visual impairment and blindness and other systemic effects as detailed in acute ingestion. Reproductive effects have been reported in animals.

SECTION 12 - ECOLOGICAL INFORMATION

ECOTOXICITY:

FISH TOXICITY:

74.3 ug/L 96 hour(s) LC50 (Mortality) Gudgeon (Gobio gobio).

INVERTEBRATE TOXICITY:

383 ug/L 48 hour(s) EC50 (Immobilization) Water flea (Daphnia magna).

ALGAL TOXICITY:

200-480 ug/L 8 hour(s) (Population) Algae, phytoplankton, algal mat (Algae).

PHYTOTOXICITY:

0.1 ug/L 21 week(s) (Biochemical) Eelgrass (Zostera marina).

OTHER TOXICITY:

3.2 ug/L 3-21 day(s) (Chlorophyll) Aquatic community (Aquatic community).

FATE AND TRANSPORT:

BIOCONCENTRATION:

1200 ug/L 48 hour(s) ECF (Residue) Bluegill (*Lepomis macrochirus*) 2.7 ug/L.

ENVIRONMENTAL SUMMARY:

Highly toxic to aquatic life.

SECTION 13 - DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous WasteNumber(s): U154. Dispose in accordance with all applicable regulations.

SECTION 14 - TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101 SHIPPING NAME-UN NUMBER:
Methanol-UN1230

U.S. DOT 49 CFR 172.101 HAZARD CLASS OR DIVISION:
3

U.S. DOT 49 CFR 172.101 PACKING GROUP:
II

U.S. DOT 49 CFR 172.101 AND SUBPART E LABELING REQUIREMENTS:
FLAMMABLE LIQUID; POISON

U.S. DOT 49 CFR 172.101 PACKAGING AUTHORIZATIONS:

EXCEPTIONS:
49 CFR 173.150

NON-BULK PACKAGING:
49 CFR 173.202
BULK PACKAGING:
49 CFR 173.242

U.S. DOT 49 CFR 172.101 QUANTITY LIMITATIONS:

PASSENGER AIRCRAFT OR RAILCAR:
1 L

CARGO AIRCRAFT ONLY:
60 L

SECTION 15 - REGULATORY INFORMATION

TSCA Status	: Y
TSCA 12(b) export notification	: Not listed.
CERCLA Section 103 (40 CFR 302.4)	: Y
SARA Section 302 (40 CFR 355.30)	: N TPQ
SARA Section 304 (40 CFR 355.40)	: N RQ
SARA Section 313 (40 CFR 372.65)	: Y
California Prop 65 Status	: N
SARA ACUTE Hazard	: Y
SARA CHRONIC Hazard	: Y
SARA FIRE Hazard	: Y
SARA REACTIVITY Hazard	: N
SARA SUDDEN RELEASE Hazard	: N
WHMIS Classification	: N

INTERNATIONAL REGULATIONS:
EU RISK AND SAFETY PHRASES:

SECTION 16 - OTHER INFORMATION

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APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

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APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

This document serves as the site-specific Quality Assurance Project Plan (QAPP) for Phase II Remedial Investigation (RI) and Feasibility Study (FS) activities at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington.

1.1 Plan Description

This QAPP presents the overall policies, data quality objectives (DQOs), specific quality assurance (QA) and quality control (QC) requirements, procedures, responsibilities, chain-of-custody procedures, laboratory analyses, and documentation that will be employed during Phase II RI/FS activities at the Seattle ANGS.

1.2 Remedial Investigation/Feasibility Study Description

The purpose of the RI (Phases I and II) is to provide an accurate, precise, and representative summary of the current vertical and horizontal extent of contamination in soil and groundwater associated with IRP Site 1 - Burial Site. Data obtained during the RI will be used during the FS phase as the scientific basis for identifying and selecting the most appropriate remedial alternatives for the site. This QAPP provides information regarding data collection and QA procedures to ensure that the data obtained during Phase II RI/FS activities are valid and usable for the FS decision process. The QAPP for the Phase I RI/FS is contained in *Installation Restoration Program (IRP) Final Remedial Investigation/Feasibility Study Work Plan, 143rd Combat Communications Squadron, Seattle Air National Guard Station, Seattle, Washington* (ERM, July 1996).

1.3 Remedial Investigation/Feasibility Study Project Objectives

The purpose of the QAPP is to establish standard procedures to ensure that the integrity, accuracy, precision, completeness, and representativeness of the samples are maintained in order to support the objectives of the RI/FS. The specific objectives of the RI/FS are as follows:

- Provide data to assist in defining the vertical and horizontal extent and magnitude of soil and groundwater contamination at the investigated site.
- Define site physical features, facilities, and hydrogeologic conditions that could affect contaminant migration, containment, or cleanup.
- Determine the nature and extent of potential threats to human health and the environment.
- Determine the types of response actions to be considered (decision document, FS, remedial design, or remedial action).
- Develop, screen, and evaluate remedial alternatives.
- Recommend the most cost-effective remedial alternatives that adequately protect human health, welfare, and the environment.

1.3.1 Data Usage

The data collected during the RI will provide the basis for decisions regarding remedial measures to ensure that concentrations of identified contaminants comply with applicable state and federal requirements. Specifically, the data collected during the RI will be used to:

- Characterize on-site sources of contamination;
- Determine the nature and extent of contamination and migration/exposure pathways; and
- Support the selection of cost-effective remedial technologies and alternatives.

1.3.2 Data Quality Objectives

DQOs are quantitative and qualitative objectives for ensuring that data of known and appropriate quality are obtained during the RI/FS to support the selection of appropriate remedial actions. DQOs are selected based on the specific use of the data collected.

1.3.3 Integration of DQOs

DQOs were developed through a three-stage process. The DQO process is an integral part of work plan development that includes field screening and sampling, sample shipment to the analytical laboratory, sample analysis, and reporting. The DQO process will be revised, as needed, based on the results of each data collection activity. The general DQO development process is outlined on Table B-1.

TABLE B-1

***DQO Three-Stage Development
143rd CCSQ, Seattle ANG, Seattle, Washington***

STAGE	DESCRIPTION
1	Stage 1 of the DQO process identifies the individuals responsible for decisions, data uses, and available data; and determines if additional data is needed and the types of decisions that will be made regarding site remediation. Stage 1 specifies the decision making process, identifies why additional data are needed, and sets the foundation for Stages 2 and 3 of the DQO development process.
2	Stage 2 specifies the data (quantity and quality) necessary to meet the objectives set in Stage 1. This stage stipulates the criteria for determining data adequacy. Stage 2 includes selection of the sampling approaches and the analytical options used for each site.
3	Stage 3 specifies how to assemble data collection components and develop data collection documentation. Methods were specified by which acceptable data will be obtained to make decisions. This information will be provided in the site-specific sampling plan.

1.3.4 Stages of DQOs

Stage 1 DQOs applicable to the RI/FS include the following:

- The Project Manager and Site Manager will be responsible for all decisions regarding actions taken to respond to field data. They are also responsible for determining personal protection levels, for

example, in response to site monitoring readings by field personnel. In all cases, the health and safety of field personnel will be protected.

- The Site Manager will be responsible for ensuring that the calibration of field instruments is checked and adjusted as necessary before use each day according to manufacturers' instructions. All calibration actions will be recorded in the field log in indelible ink.
- Field-screening measurements will be used to initially characterize each site during drilling and sampling activities. If field-screening measurements identify local areas of elevated contamination, the field sampling plan may be modified by the Project Manager upon approval by the Air National Guard (ANG) Project Manager, in order to accurately assess the contamination.

Stage 2 DQOs applicable to the RI/FS include the following:

- The field geologist will be responsible for ensuring that the required volume of each sample matrix is collected to ensure that complete laboratory analysis objectives are met.
- The field geologist is responsible for ensuring that all QA/QC samples are collected in accordance with the field sampling plan and this QAPP.
- Personnel exposure to airborne contaminants will not exceed applicable Threshold Limit Values. Sites will be continuously screened to ensure that field personnel are not exposed to contaminants that would be harmful to their health and safety.
- Samples will be strictly controlled in accordance with ANG site investigation protocol. Samples will be collected using only decontaminated equipment. The Site Manager will be responsible for ensuring that ANG protocols for decontamination and sampling are met. In accordance with the field sampling plan, care will be taken to eliminate cross-contamination during sampling activities.

Stage 3 DQOs applicable to the RI/FS include the following:

- Documentation is key to ensuring that the highest levels of accuracy, precision, completeness, representativeness, and comparability are met. Accordingly, all field personnel will be trained and familiar with standard documentation requirements. Training will include

information on how analytical data will be used for site investigation decisions.

- The Work Plan will be approved by the ANG prior to implementation and will include complete matrix and QA/QC sampling requirements.
- All field notes taken during sampling activities will be recorded in field log books using indelible ink.
- Samples will be labeled using a standard sample label, with all required data elements included.
- Sample data will be entered on the Chain-of-Custody Record to ensure proper sample tracking and control.
- Samples will be shipped in sealed containers and accompanied by the Chain-of-Custody Record.
- QA/QC samples, including trip blanks, equipment blanks, field duplicates, and matrix spike/matrix spike duplicates will be collected, controlled, and shipped in the same manner as normal field samples, to ensure that field collection protocols will produce accurate site data and that laboratory analytical procedures meet the highest standards of performance.
- Complete and traceable Chain-of-Custody Records will be maintained to document that proper sampling and QA/QC protocols were observed in data collection and analysis. Only traceable data will be used for decision-making regarding further sampling requirements, site remediation, or site closure.

1.4 Quality Assurance Objectives for Measurement Data

The overall QA objective is to develop and implement procedures that will ensure quality in field sampling, field testing, chain-of-custody, laboratory analysis, data analysis, and data reporting. Specific procedures for sampling, chain-of-custody, audits, preventive maintenance, and corrective actions are described in other sections of this QAPP. This section defines the numeric quantitation and QC limits for ensuring that analytical data of appropriate accuracy and precision are obtained. QC during field sampling is also discussed.

1.4.1 Regulatory Parameters

Analysis of soil and groundwater samples collected during the Phase II RI/FS will be performed in accordance with analytical procedures that conform to United States Environmental Protection Agency (USEPA) guidelines published in *Test Methods for Evaluating Solid Wastes (SW-846), Third Edition* (update package, December 1997).

Washington State soil and groundwater cleanup levels for volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPH) (the constituents of interest during the Phase II RI) are presented on Table B-2. Soil and groundwater cleanup levels will be recalculated as necessary for the Phase II RI/FS report to account for changes in federal Maximum Contaminant Levels (MCLs) and/or toxicological data as published in Model Toxics Control Act (MTCA) risk calculation updates. The practical quantitation limits for some of the constituents listed on Table B-2 are higher than the MTCA method B cleanup levels. The Washington State Department of Ecology (WDOE) recognizes this situation and provides guidance regarding adopting practical quantitation limits as cleanup levels (WDOE, 1995).

Tables B-3 and B-4 summarize the quantitation limits for VOCs analyzed by USEPA Methods 8260 and 8010/8020. Maximum quantitation limits for TPH in soil and groundwater are 30 milligrams per kilogram (mg/kg) and 1 milligram per liter (mg/l), respectively. Required holding times for soil and water samples are summarized on Table B-5.

1.4.2 Sampling Plan for Phase II Remedial Investigation

The sampling plan for the Phase II RI is summarized in the main text of the Phase II RI/FS Work Plan.

1.4.3 Quality Control During Field Sampling

Field duplicate samples and equipment rinsate blanks, field blanks, and trip blanks will be submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field sampling program. Rinsate, field, and trip blanks will be analyzed to check for contamination associated with sampling procedures and/or ambient conditions at the site. Duplicate samples will be submitted using nonindicative sample identifiers to provide a QA check on analytical procedures and results.

TABLE B-2
 Washington Soil and Groundwater Cleanup Levels for VOCs and TPH
 143rd CCSQ, Seattle ANG, Seattle, Washington

ANALYTICAL GROUP	GROUNDWATER Concentration in µg/l				SOIL Concentration in mg/kg	
	Primary MCL	Secondary MCL	MTCA - Method A	MTCA - Method B	MTCA - Method A Residential/Industrial	MTCA - Method B
VOLATILE ORGANIC COMPOUNDS (VOCs)						
Benzene	5	—	5.0	1.3	0.5 / 0.5	34.5
Bromodichloromethane	100*	—	—	0.7	—	16.1
Bromoform	100*	—	—	5.5	—	127
Bromomethane	—	—	—	11.2	—	112
Carbon disulfide	—	—	—	800	—	8,000
Carbon tetrachloride	5	—	—	0.33	—	7.7
Chloroform	100*	—	—	7.17	—	154
Chlorobenzene	100	—	—	160	—	1,600
Ethylbenzene	700	—	30	800	20 / 20	8,000
Methylene chloride	5	—	5	—	0.5 / 0.5	—
Toluene	1,000	—	40	1,600	40 / 40	16,000
Trichloroethylene	5	—	5	3.98	0.5 / 0.5	90.9
Tetrachloroethylene	5	—	5	0.86	0.5 / 0.5	19.6
Trihalomethanes (total)	100*	—	—	—	—	—
1,2-Dichloroethane	5	—	5	0.49	—	11
cis-1,2-Dichloroethylene	70	—	—	80	—	800
trans-1,2-Dichloroethylene	100	—	—	160	—	16,000
1,1-Dichloroethylene	7	—	—	0.07	—	1.67
Styrene	100	—	—	1.46	—	33.3
1,2-Dichloropropane	5	—	—	0.66	—	14.7
1,1,2,2-Tetrachloroethane	—	—	—	3.68	—	38.5
1,1,1-Trichloroethane	200	—	200	7200	20 / 20	72,000
Vinyl Chloride	2	—	0.2	0.02	—	0.53
1,1,2-Trichloroethane	5	—	—	0.77	—	17.5
Xylenes (total)	10,000	—	20	16,000	20 / 20	160,000
Monochlorobenzene	100	—	—	—	—	—
1,3-Dichlorobenzene	75	—	—	—	—	—
1,4-Dichlorobenzene	600	—	—	1.8	—	41.7
TOTAL PETROLEUM HYDROCARBONS (TPH)						
TPH as gasoline	—	—	1,000	(a)	100 / 100	(a)
TPH as diesel	—	—	1,000	(a)	200 / 200	(a)
TPH (other)	—	—	1,000	(a)	200 / 200	(a)

Sources: WDOE, 1993 and 1994

µg/l = micrograms per liter

mg/kg = milligrams per kilogram

— = Not available

MCL = Federal Maximum Contaminant Level

* MCL for total trihalomethanes including bromoform, bromodichloromethane, chloroform, and dibromochloromethane

MTCA = Model Toxics Control Act

VOCs = Volatile organic compounds

TPH = Total petroleum hydrocarbons

PQL = Practical quantitation limit

Bold typeface/shading = PQL is greater than cleanup standard

(a) = Site-specific method B cleanup levels are calculated based on *Interim Interpretive and Policy Statement - Cleanup of Total Petroleum Hydrocarbons* (WDOE, 1997)

TABLE B-3
Accuracy, Precision, and PQL Limits for Method 8260
143rd CCSQ, Seattle ANG, Seattle, Washington

Target Analyte	Soil			Groundwater		
	PQL µg/kg	QC Limits (a)		PQL µg/l	QC Limits (a)	
		Recover	RPD		% Recovery	RPD
Chloromethane	5			5		
Vinyl Chloride	5			5		
Bromomethane	5			5		
Chloroethane	5			5		
Trichlorofluoromethane	5			5		
Acetone	10			10		
2-Chloroethyl vinyl ether	20			20		
1,1-Dichloroethylene	5	59 - 172	22	5	64 - 124	14
Methylene Chloride	5			5		
Carbon Disulfide	5			5		
Vinyl Acetate	10			10		
1,1-Dichloroethane	5			5		
2-Butanone	10			10		
trans-1,2-Dichloroethylene	5			5		
cis-1,2-Dichloroethylene	5			5		
Chloroform	5			5		
1,1,1-Trichloroethane	5			5		
Carbon Tetrachloride	5			5		
1,2-Dichloroethane	5			5		
Benzene	5	66 - 142	21	5	67 - 127	11
Trichloroethylene (TCE)	5	62 - 137	24	5	60 - 120	14
1,2-Dichloropropane	5			5		
Bromodichloromethane	5			5		
4-Methyl-2-pentanone	10			10		
2-Hexanone	10			10		
cis-1,3-Dichloropropene	5			5		
trans-1,3-Dichloropropene	5			5		
1,1,2-Trichloroethane	5			5		
Toluene	5	59 - 139	21	5	72 - 132	13
Dibromochloromethane	5			5		
Tetrachloroethylene (PCE)	5			5		
Chlorobenzene	5	60 - 133	21	5	68 - 128	13
Ethylbenzene	5			5		
m,p-Xylenes	5			5		
o-Xylene	5			5		
Styrene	5			5		
Bromoform	5			5		
1,1,2,2-Tetrachloroethane	5			5		
1,3-Dichlorobenzene	5			5		
1,4-Dichlorobenzene	5			5		
1,2-Dichlorobenzene	5			5		

PQL- Practical Quantitation Limit

QC - Quality Control

RPD - Relative Percent Difference

µg/kg - micrograms per kilogram

µg/l - micrograms per liter

(a) - Limits should be viewed as goals and not as a means of accepting or rejecting data. QC limits apply to both matrix spike and laboratory control sample recoveries.

TABLE B-4

*Accuracy, Precision, and PQL Limits for Methods 8010/8020
143rd CCSQ, Seattle ANG, Seattle, Washington*

Target Analyte	PQL µg/l	QC Limits (a)	
		% Recovery	RPD
Dichlorodifluoromethane	5		
Chloromethane	5		
Bromomethane	5		
2-Chloroethylvinyl ether	10		
Vinyl Chloride	5		
Chloroethane	5		
Methylene Chloride	1		
Trichlorofluoromethane	5		
1,1-Dichloroethylene	1		
1,1-Dichloroethane	1		
trans-1,2-Dichloroethylene	1	20	75-125
Chloroform	1		
1,2-Dichloroethane	1	20	75-125
1,1,1-Trichloroethane	1	20	75-125
Carbon Tetrachloride	1		
Bromodichloromethane	1	20	75-125
1,2-Dichloropropane	1		
trans-1,3-Dichloropropene	1	20	75-125
Trichloroethylene	1		
Chlorodibromomethane	1		
1,1,2-Trichloroethane	1	20	75-125
cis-1,3-Dichloropropene	1	20	75-125
Bromoform	2	20	75-125
1,1,2,2-Tetrachloroethane	2		
Tetrachloroethylene (PCE)	2		
Chlorobenzene	2		
Benzene	1	20	75-125
Toluene	1	20	75-125
Ethylbenzene	1	20	75-125
p-Xylene	1		
m-Xylene	1		
o-Xylene	1		
1,2-Dichlorobenzene	5		
1,3-Dichlorobenzene	5		
1,4-Dichlorobenzene	5		

Note: Sample PQLs are matrix-dependent. The PQLs listed in the table are provided for guidance and may not always be achievable.

PQL- Practical Quantitation Limit

QC - Quality Control

RPD - Relative Percent Difference

µg/l - micrograms per liter

(a) - Limits should be viewed as goals and not as a means of accepting or rejecting data. QC limits apply to both matrix spike and laboratory control sample recoveries.

TABLE B-5

*Summary of Sample Holding Times for Water and Soil Samples
143rd CCSQ, Seattle ANG, Seattle, Washington*

Parameter	Holding Time
	<u>Water Samples</u>
VOCs	Analyze within 14 days of collection.
TPH	Extract within 14 days of collection and analyze within 40 days of extraction.
	<u>Soil Samples</u>
VOCs	Analyze within 14 days of collection.
TPH	Extract within 7 days of collection and analyze within 40 days of extraction.

VOCs = Volatile organic compounds

TPH = Total petroleum hydrocarbons

QC for soil sample collection will include the following:

- Field duplicate samples and equipment rinsate blanks and field blanks will be collected at a frequency of 10 percent of the total number of original samples.
- One trip blank for VOC analysis will be included with each ice chest containing samples for VOC analysis. The trip blank will be prepared using ASTM Type II reagent grade water (or equivalent).

QC for groundwater sample collection will include the following:

- Field duplicate samples and equipment rinsate blanks and field blanks will be collected at a total frequency of 10 percent of the total number of original samples.
- One trip blank for VOC analysis will be included with each ice chest containing samples for VOC analysis. The trip blank will be prepared using ASTM Type II water (or equivalent).

Matrix spike samples provide information about the effect of the sample matrix on the analytical methodology. Matrix spike analyses are performed in the analytical laboratory. All matrix spikes are performed in duplicate. Samples designated as matrix spike/matrix spike duplicate samples are investigative samples collected at triple the volume for VOCs and double the volume for the remaining analytes. One matrix spike/matrix spike duplicate will be designated for every 20 samples per sample matrix (water and soil matrices).

QC for field measurements (e.g., pH, specific conductance, and turbidity) consists of a pre-measurement calibration and a post-measurement verification using standard reference solutions in accordance with the manufacturer's recommendations. These procedures will be performed at least once per day or more often as necessary. QC for field measurement of temperature will include measurement with a second measuring device.

Holding times for water and soil samples are summarized on Table B-5. Holding times are defined as the maximum length of time that samples may be held before the completion of analytical protocols. All samples will be chilled in a temperature range between 2° and 4° C and will be maintained at that temperature through transport and subsequent storage

at the analytical laboratory. Samples will not be retained on site over 24 hours unless prior approval is received from the ANG Project Manager.

1.4.3.1 Groundwater Sample Preservation

Samples collected for VOC analysis will be preserved with no more than two drops of a 1:1 solution of hydrochloric acid per 40-milliliter glass VOC vial. The vial will have a Teflon-lined septa within the lid. VOC samples will be stored in an ice chest.

1.4.3.2 Soil Sample Preservation

Soil samples submitted for laboratory analysis will be contained in brass sample tubes. Immediately upon removal from the drive sampler or hand auger, the ends of the filled brass tubes will be covered first with Teflon (a moisture barrier), aluminum foil, and then with a fitted plastic cap. Samples will then be placed in individual, self-sealing bags and stored in an ice chest with enough ice to maintain samples at a temperature of less than 4° C.

1.5 Accuracy, Precision, and Sensitivity of Analyses

The accuracy, precision, and sensitivity of laboratory analytical data must satisfy the QC acceptance criteria of the analytical protocols. Quantitation and QC limits required for aqueous and solid matrices analyzed per USEPA protocols are shown on Tables B-3 and B-4.

1.5.1 Quality Assurance Objective for Accuracy

Analytical accuracy is calculated by expressing, as a percentage, the recovery of an analyte that has been added to the sample (or standard matrix) at a known concentration before analysis and is expressed in the following formula:

$$\text{Percent Recovery} = \frac{(\text{SSR}-\text{SR})}{\text{SA}} \times 100$$

Where

SSR = Spiked Sample Result;
SR = Sample Result; and

SA = Spike Added.

The spiked concentration will be specified by laboratory QC requirements or may be determined relative to the background concentrations observed in the nonspiked sample. In the latter case, the spiked concentration should be significantly higher (two to five times higher) than the background concentration to permit a reliable recovery calculation.

For volatile organic analysis by gas chromatography (GC) and GC/mass spectrometry, analytical accuracy is obtained from the surrogate recovery measured in each sample and blank or from the analysis of samples or blanks spiked with a select number of target analytes.

The QA objectives for surrogate recovery are summarized on Table B-6. The QA objectives for matrix spike recovery are summarized on Tables B-3 and B-4. Failure to achieve these recoveries will trigger corrective action. The recovery values for surrogate and target analytes in field sample analyses are advisory for routine laboratory analytical services.

1.5.2 Quality Assurance Objective for Precision

Analytical precision is calculated by expressing, as a percentage, the difference between the results of analysis of duplicate samples relative to the average of those results for a given analyte. Precision can be expressed by the following formula:

$$\text{RPD} = \frac{(\text{SPL1} - \text{SPL2})}{\text{Mean of SPL1 and SPL2}} \times 100$$

Where

RPD = Relative Percent Difference;
 SPL1 = First sample value (original); and
 SPL2 = Second sample value (duplicate).

The QA objectives for analytical precision are summarized on Tables B-3 and B-4. Failure to achieve these objectives will trigger corrective action.

1.5.3 Completeness, Representativeness, and Comparability

Completeness is a measure of the relative number of analytical data points that meet all the acceptance criteria for accuracy, precision, and any other

TABLE B-6

*Quality Assurance Objectives for Accuracy of Surrogate Spike Samples
143rd CCSQ, Seattle ANG, Seattle, Washington*

Compound/Method	Surrogate Compound	Water Percent Recovery Limits	Low/Medium Soil Percent Recovery Limits
VOCs/8260	Bromofluorobenzene	86-115	74-121
VOCs/8260	1,2-Dichloroethane-d	76-114	70-121
VOCs/8260	Toluene-d8	88-110	81-117

VOCs = Volatile organic compounds

Note: These limits are for advisory purposes only. They are not used to determine whether a sample should be reanalyzed.

criteria required by the specific analytical methods used. The percent of completeness for analytical data can be expressed by the following formula:

$$\text{Percent Completeness} = (V/T) \times 100$$

Where

V = Number of valid data points; and
T = Total number of data points.

The QA objective for analytical data completeness for the RI/FS is 90 percent. The ability to meet or exceed this objective depends on the nature of the samples submitted for analysis.

The sampling plan has been designed to provide data representative of site conditions. During development of the sampling methodologies, consideration was given to past waste disposal practices, existing analytical data, physical setting, and constraints inherent to the program.

The extent to which existing and planned analytical data will be comparable depends on the similarity of sampling and analytical methods. The procedures used to collect data for the Phase II RI, as documented in this QAPP, are expected to provide analytical data that are comparable to the Phase I RI data. However, the data collected during the Phase I and II RI may not be directly comparable to previous data collected at the site because of possible differences in the sampling and/or analytical procedures and QA objectives.

1.6 Field Measurements

Most data collected during the RI/FS will be based on laboratory analysis of samples collected at the investigation site. There are certain data, such as groundwater parameters (i.e., specific conductance, temperature, turbidity, and pH) that will be collected and directly recorded in the field. The primary QA objectives for field activities should verify that QC checks are performed, measurements are obtained to the degree of accuracy consistent with their intended use, and documentation is generated to verify adherence to required measurement procedures.

Surveying and mapping at the Seattle ANGS will be conducted to provide a common frame of reference for RI/FS activities. Surveying will be

performed by a surveyor registered in the State of Washington. Surveying of monitoring wells and soil borings will be completed to an accuracy of ± 0.1 foot horizontally and ± 0.01 foot vertically. Bench marks used during the survey will be permanent marker(s) that will be tied to National Geodetic Vertical Datum (NGVD) Mean Sea Level using either U.S. Coast and Geodetic Survey or U.S. Geological Survey monuments.

The recording of field data will follow standard reporting procedures as follows:

- Soil sampling depths will be reported to the nearest 0.1 foot.
- All temperatures will be recorded to the nearest 0.1°C
- pH will be reported to 0.1 standard units.
- Depth to groundwater in monitoring wells will be reported to the nearest 0.01 foot.
- Photoionization detector (PID) measurements will be reported in parts per million (ppm) and will be reported with the maximum precision attainable in the instrument range scale used for the measurement.
- Specific conductance will be reported in microsiemens and will be reported with the maximum precision attainable in the instrument range scale used for the measurement.
- Turbidity will be reported in nephelometric turbidity units and will be reported with the maximum precision attainable in the instrument range scale used for the measurement.

1.7 Sampling Procedures

Procedures used for collecting environmental samples will follow standard operating procedures (SOPs) developed for Environmental Resources Management's (ERM's) Installation Restoration Program (IRP) work and will conform to ANG site investigation protocol. The SOPs are included in Appendix B of ERM's IRP Program Quality Assurance Program Plan (ERM, 1995). The Site Manager is responsible for ensuring that samples are collected with properly decontaminated equipment and contained in proper sample containers with appropriate preservatives. The steps required for sample control and identification, data recording,

and chain-of-custody documentation are included in the IRP Quality Assurance Program Plan.

Prior to the beginning of each sampling event, the Project Manager will meet with the assigned sampling personnel and review the purpose and objectives of the sampling. This meeting will provide final clarification of the sampling event details. Topics of review and discussion will include the following: sampling locations; types of samples to be collected; number of samples to be collected; sample identifiers; constituents to be analyzed; sampling procedures; sampling equipment decontamination procedures; and chain-of-custody documentation requirements.

Equipment decontamination is an integral part of the data collection and QA process. The implementation of proper decontamination practices and procedures will begin in the field prior to the use of sample collection equipment. All field sampling equipment will be decontaminated before and after use, in accordance with ANG protocols. Wash water and other fluids created during decontamination will be containerized and will be disposed of properly.

1.7.1 Soil Sampling

Subsurface soil samples will be collected using a hollow-stem auger or Geoprobe drill rig equipped with a split-spoon (or equivalent) drive sampler. The drive sampler will be constructed of stainless steel and lined with brass sample tubes. Augers, drill rods, the drill rig, and other drilling equipment will be decontaminated before each new soil boring. The drive sampler will be decontaminated before each new soil sample. Equipment decontamination procedures are detailed in the Phase II RI/FS Work Plan.

1.7.2 Groundwater Sampling

The following procedures will be used during groundwater sampling activities at monitoring wells:

- Immediately prior to collecting a sample, the static water level will be measured with reference to the monitoring well's measuring point and will be recorded in the field notebook.
- Whenever feasible, monitoring wells will be sampled in order of increasing concentration of contaminants, based on analysis of samples collected during previous sampling events.

- Prior to collecting a sample, water in the well casing will be purged at a rate of less than 1 liter per minute using a non-dedicated submersible sampling pump. The temperature, pH, specific conductance, and turbidity of the purge water will be monitored during well purging using an in-line flow cell and portable water quality test meter. The purging will continue until the temperature, pH, specific conductance, and turbidity of the purge water have stabilized to within ± 10 percent. The amount of water purged from each well will be measured and recorded.
- Monitoring wells will be sampled directly from the pump discharge or with a disposable polyethylene sampling bailer. The pump discharge hose will be thoroughly decontaminated before each well is sampled.
- Sampling equipment will be kept off of potentially contaminated surfaces to prevent cross-contamination of the samples (e.g., equipment will be placed on plastic sheeting).
- The calibration of the portable water quality test meter used to monitor field parameters during well purging will be checked and adjusted as necessary according to manufacturer's recommendations, at the beginning of each day and periodically during the day as required.

1.8 Sample Chain-of-Custody Procedures

Sample chain-of-custody procedures require that possession and handling of all samples be documented from the moment of its collection through the time of completion of laboratory analyses. The Chain-of-Custody Record must clearly reflect the movement of the sample through the sample handling and transport process to ensure that proper custody has been maintained and that the sample has not been tampered with in any way. A sample is judged to be in proper custody when at least one of the following criteria has been met:

- The sample is in one's actual physical possession;
- The sample is in one's clear field of view after being in one's physical possession;
- The sample is in one's physical possession and is then locked up in a secure container so that no one can tamper with it; or

- The sample is kept in a secured area that can be accessed by authorized personnel only.

1.8.1 Sample Labels

All samples will be identified with a label or permanent marker applied directly to the container. Sample identification information will be completed using waterproof ink and will consist of the following:

- Unique sample identifier;
- Time and date of collection;
- Site name;
- Preservative (if any); and
- Sampler's initials.

1.8.2 Chain-of-Custody Record

To maintain a record of sample collection, transfer between sample custodians, shipment, and receipt by the laboratory, a Chain-of-Custody Record will be filled out for all samples collected for laboratory analysis. Each time the samples are transferred, the signatures of the person relinquishing and receiving the samples, as well as the date and time of transfer, will be documented on the Chain-of-Custody Record.

1.8.3 Transfer of Custody and Shipment

Prior to the shipment of samples, the Chain-of-Custody Record will be signed and dated by a member of the field team who has verified that those samples indicated on the Chain-of-Custody Record are indeed being shipped. A copy of ERM's standard Chain-of-Custody Record is shown on Figure B-1. After packaging has been completed and the samples are closed within the ice chest, signed and dated custody seals will be placed over the edge of the ice chest lid.

Samples will be shipped by air or ground courier, or hand delivered by ERM personnel to the analytical laboratory. Samples will be transported, generally each day, by field personnel from the Station to the courier location for subsequent shipment to the laboratory. Upon receipt of the samples at the laboratory, the receiver will complete the transfer by dating

CHAIN OF CUSTODY RECORD

NO:

Page _____ of _____

[illegible]

GOLD - PROJECT FILE

FIGURE B-1

B-20

KCSlip4 41090

SEA407620

and signing the Chain-of-Custody Record. An acceptable alternative is to enter the airbill number and shipping data into the appropriate signature/date block.

A copy of the airbill is to be kept with the field copy of the Chain-of-Custody Record to document specific shipping information.

1.8.4 Laboratory Chain-of-Custody Procedures

The following describes laboratory chain-of-custody procedures associated with sample receipt, storage, preparation, analysis, and general security.

1.8.4.1 Sample Receipt

Sample receipt procedures are discussed below.

- Upon receipt, the sample custodian will inspect sample containers for integrity. The presence of leaking or broken containers will be noted on the Chain-of-Custody Record. The sample custodian will sign the Chain-of-Custody Record with the date and time of receipt, thus assuming custody of the samples.
- The information on the Chain-of-Custody Record will be compared with the information on the sample labels to verify the exact sample identity. Any inconsistencies will be immediately resolved with the field sampling representative before sample analysis proceeds.
- Samples will be moved to a locked sample storage refrigerator for storage prior to analysis. The storage location will be recorded on the Chain-of-Custody Record or Laboratory Tracking Form to ensure continuity of sample tracking.
- The sample custodian will retain the original Chain-of-Custody Record and will provide copies to each laboratory section manager and one to the laboratory's sample master log.
- The sample custodian will alert the appropriate section managers and analysts of any analyses requiring immediate attention because of short holding times.

1.8.4.2 Sample Storage

Samples requiring refrigeration will be maintained in a locked storage refrigerator which will be kept at a temperature ranging from 2° to 4° C. Analytical laboratory personnel will request samples for analysis from the sample custodian and the formal transfer action, including date and signatures, will be recorded on the Chain-of-Custody Record. The analyst will then be the custodian of the sample during analysis.

1.8.4.3 Data Recording

Raw data is calculated or reduced into reportable values in three ways at the laboratory: manually, by an external computer program, and by a data system that collects the raw data. Individual laboratories have specific data recording and data management standard operating procedures. In general, data collected on an instrument's data system are transferred electronically into the laboratory's data acquisition program. Data acquisition transfers data into the laboratory information management system for routine final reporting and is also used for generation of analytical data reports. All formulae used to calculate reported values are those specified by the analytical method and are included in internal laboratory standard operating procedures.

1.9 Documentation Procedures

Documentation procedures for sample identification and field logs are discussed below. Procedures for document corrections are also discussed.

1.9.1 Sample Identification

A standardized numbering system will be used to identify soil and groundwater samples collected during RI/FS field activities. The numbering system provides a tracking procedure to ensure accurate data retrieval of all samples collected. A listing of the sample identification numbers will be maintained by the Site Manager, who will be responsible for ensuring the standardized numbering system is followed during sampling activities.

The standard sample identifiers for field samples are coded as follows:

- Sample identifiers for primary soil samples will include the soil boring number and sample depth. For example, SB-1-5 represents a sample collected at a depth of 5 feet bgs from soil boring SB-1.
- Sample identifiers for primary groundwater samples will include the monitoring well number and the quarterly sampling round. For example, MW1-98-1 represents a groundwater sample collected during the first round of quarterly sampling in 1998 from monitoring well MW-1.

Field QA/QC sample identifiers for soil will be as follows:

- Sample identifiers for trip blanks will be as follows: TB-date-#. For example, TB-081098-1 represents the first trip blank collected on 10 August 1998.
- Sample identifiers for field duplicate samples will be the same as the original sample but followed by a "D."
- Sample identifiers for rinsate blanks and field blanks will consist of the soil boring identifier at which the blank was prepared followed by an "R" for rinsate blanks, an "FT" for tap water field blanks, or an "FA" for ASTM Type II water field blanks.

Field QA/QC sample identifiers for groundwater will be as follows:

- Sample identifiers for trip blanks will be the same as those for soil.
- Sample identifiers for field duplicate samples will be the same as the original sample but followed by a "D."
- Sample identifiers for rinsate blanks and field blanks will consist of the monitoring well identifier at which the blank was prepared followed by an "R" for rinsate blanks, an "FT" for tap water field blanks, or an "FA" for ASTM Type II water field blanks.

1.9.2 Field Logs

Data collection activities performed at the site will be documented in bound field notebooks and on Chain-of-Custody Records using indelible ink. Field notebooks will be assigned to individual field personnel for the

duration of their field activities. Entries will be as detailed and descriptive as possible so that a particular situation can be recalled without reliance solely on the sampler's memory. All field log entries will be dated and signed by the person making them.

Depending on field activities, the Site Manager may designate a member of the field team to photocopy, at the end of each day, all field notes (notebook pages and standard forms) generated during that day. Copies will be given to the Project Manager. If implemented, at the completion of a work shift, copies of all field logs, notebook pages, and standard forms will be returned to the Site Manager for subsequent delivery to the Project Manager and entry into project files.

The Site Manager will maintain a separate Site Log summarizing daily field activities, outside visitors, communications, sample shipments, and equipment assignments. This log will become a part of the original project files.

1.9.3 Corrections to Documentation

If an incorrect entry is made in any type of data document, the incorrect entry will be crossed out with a single line, the correct information entered, and the correction initialed and dated by the person making the correction. Like original entries, corrections will be made in indelible ink.

1.9.4 Final Evidence File Documentation

Records will be kept in the project files to document QA/QC activities and to provide support for possible evidential proceedings. The following outline of project file requirements applies to project activities:

Communications

- Internal
- External
- QA/QC
- Procedures
- Chain-of-Custody Documentation

- Audit Reports
- Laboratory QA Reports
- Deviation Notification Forms
- Nonconformance/Corrective Action Reports

Technical Information

- Analytical Data
- Field Data
- Field Logbooks
- Graphic Resources
- Data Quality Acceptance
- Calculations/Evaluations
- Regulatory Compliance

Project Management

- Project Schedule
- Budget
- Site Database Information

Health and Safety

- Plans/Procedures
- Audit Reports

Documents

- Plans
- Reports
- Relevant Publications

ERM will maintain all evidential file documentation using its internal project file system. Upon completion of the project, the original project files will be archived. Copies of file documentation will be provided to the ANG upon request. The Project Manager will ensure that all records, including QA/QC records, are properly stored and retrievable.

1.10 Calibration Procedures and Frequency

The following sections summarize calibration procedures for field and laboratory equipment.

1.10.1 Field Equipment

The analytical and health and safety screening instruments that may be used in the field during the Phase II RI/FS are:

- PID;
- Conductivity Meter;
- pH Meter;
- Turbidity Meter; and
- Temperature Meter.

The instruments will be calibrated according to manufacturers' specifications before and after each field use, or as otherwise required. Where necessary, instruments will be calibrated each day during field use.

1.10.1.1 Photoionization Detector

A calibration check of the PID will be performed at the start of each day using a standard calibration gas. Additional calibration checks and instrument adjustments will be made if the unit experiences abnormal perturbations or readings become erratic. Results of the calibration check will be recorded in the field notebook in indelible ink. Calibration procedures will follow manufacturer's instructions.

1.10.1.2 Conductivity Meter

Calibration will be performed at the start of each sampling day using a standard solution of potassium chloride. The meter will be adjusted to

read the value of the standard. The meter must read within 10 percent of the standard to be considered in control and should read within 5 percent (7 percent is considered a warning level). If the calibration indicates the meter readings are out of the control limits, a backup unit should be used. If a backup unit is not available, the data will be flagged to note the percent difference between the meter and the standard calibration solution. Readings from conductivity meters lacking calibration adjustments are normally stable; thus, calibration checks are usually limited to the beginning and end of the sampling day.

1.10.1.3 pH Meter

Calibration will be performed at the start of each sampling day using buffer solutions that bracket the pH range expected in the samples. The pH meter will be adjusted to read the value of the standard. The meter is checked during the sampling day, using at least one standard, at a frequency which results in little or no calibration adjustment. If the reading varies more than one-tenth of a pH unit between calibration checks, the frequency of the checks must be increased.

1.10.1.4 Turbidity Meter

Calibration will be performed at the start of each sampling day using a formazin solution. The turbidity meter will be adjusted to read the value of the standard. The meter is checked during the sampling day, using at least one standard, at a frequency which results in little or no calibration adjustment. If the reading varies more than one-tenth of a turbidity unit between calibration checks, the frequency of the checks must be increased.

1.10.1.5 Temperature Meter

Temperature will be measured by either using a thermostat built into the specific conductance meter or a separate thermometer unit. Temperature readings will be checked at least once per field trip using a quality-grade (preferably National Bureau of Standards traceable) thermometer. Should the unit experience erratic or out-of-tolerance readings, additional checks will be performed.

1.10.2 Laboratory Equipment

Before any laboratory instrument is used as a measuring device, the instrument response to known reference materials must be determined. The manner in which various instruments are calibrated is dependent on

the particular type of instrument and its intended use. Sample measurements will be made within the calibrated range of the instrument.

Laboratory calibrations typically consist of two types, initial calibration and continuing calibration. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. Continuing calibration usually includes measurement of the instrument response to one or more calibration standards and requires instrument response to compare with certain limits (e.g., ± 10 percent) of the initial measured instrument response.

Specific laboratory instrument calibration procedures for various instruments are described in detail in the Laboratory Quality Assurance Project Plan for the analytical laboratory selected to perform the analyses.

1.11 Analytical Procedures

The following sections summarize the analytical procedures for field activities and the laboratory.

1.11.1 Field Parameters

As part of the analytical protocol for groundwater samples, several parameters will be tested in the field. Monitoring well purge water will be tested for specific conductance, temperature, pH, and turbidity. The field parameters will be measured using an in-line flow cell.

1.11.2 Laboratory Methods

Groundwater and soil samples collected will be analyzed using the analytical methods specified in the Phase II RI/FS Work Plan.

1.12 Internal QC Check Procedures

The following sections summarize internal QC check procedures for laboratory analysis and field measurements.

1.12.1 Routine Analytical Services

Internal QC procedures for routine analytical services are specified in the USEPA's method descriptions. These specifications include the types of QC checks required (sample spikes, surrogate spikes, reference samples, controls, and blanks), the frequency of each audit, the compounds to be used for sample and surrogate spikes, and QC acceptance criteria for these checks.

1.12.2 Field Measures

QC procedures for field measurements are linked to checking the reproducibility of the measurements by obtaining multiple readings and by calibrating the instruments (when appropriate). QC of field sampling will involve collecting field duplicates and blanks in accordance with the applicable procedures described in this QAPP.

1.13 Data Reduction, Validation, and Reporting

The following sections summarize reduction, validation, and reporting procedures for field, technical, and laboratory data.

1.13.1 Field and Technical Data

The field and technical (non-laboratory) data that will be collected can generally be characterized as either objective or subjective data. Objective data include all direct measurements, such as field screening/analytical parameters and water level measurements. Subjective data include activity descriptions and field observations.

1.13.1.1 Field and Technical Data Reduction

As described in previous sections, field data will be recorded by field personnel in bound field notebooks and on standard forms. For example, during drilling activities, the field team member supervising a rig will keep a chronological log of drilling activities, a vertical descriptive log of lithologies encountered, other pertinent drilling information (i.e., staining, odors, field-screening results, working conditions, and water levels) in his/her bound notebook. The Site Manager may choose to appoint a team member to photocopy all field logs (including notebook pages and standard forms) generated in a given field day. Copies will be given to

the Site Manager who will maintain a field log file. At the direction of the Project Manager, copies of all field logs, notebook pages, and standard forms will be returned to the office for entry into project files.

After checking the validity of data in field notes and on standard forms, the Project Manager will be responsible for entering pertinent data into project data files. Where appropriate, the data files will be set up for direct input into the project database. Subjective data will be filed as hard copies for later review by the Project Manager and for incorporation into technical reports as appropriate.

1.13.1.2 Field and Technical Data Validation

Validation of objective field and technical data will be performed at two different levels. On the first level, data will be validated at the time of collection by following standard procedures and QC checks. At the second level, data will be validated by the Project Manager, who will review the data to ensure that the correct codes and units have been included. After data reduction into tabular format or the project database, the Project Manager will review data sets for anomalous values. Any inconsistencies or anomalies discovered will be resolved immediately, if possible, by seeking clarification from field personnel responsible for collecting the data.

Subjective field and technical data will be validated by the Program Manager, who will review field reports for reasonableness and completeness. In addition, random checks of sampling and field conditions will be made by the Project Manager or Site Manager who will check recorded data at that time to confirm the recorded observations. Whenever possible, peer review will also be incorporated into the data validation process, particularly for subjective data, to maximize consistency among field personnel. For example, during drilling activities, the Project Manager or Site Manager will schedule periodic reviews of archived lithologic logs to ensure that proper lithologic descriptions and codes have been consistently applied by field personnel.

1.13.2 Laboratory Data

As described earlier, analytical data will be recorded in three ways: manually; an external computer program; and a data system that collects the raw data. Data collected on an instrument's data system are transferred electronically into the laboratory's data acquisition program. Data acquisition transfers data into the laboratory information

management system for routine final reporting and is also used for production of analytical data reports. Copies of strip-chart outputs (e.g., chromatograms) will be maintained on file at the laboratory.

1.13.2.1 Laboratory Data Reduction

At the completion of a set of analyses, all calculations will be completed and checked by the analyst. The associated QC data (blanks, blank spikes, duplicates) are entered onto QC charts and are verified to be within control limits. If all data are acceptable, the data are entered into the laboratory computer system, and data summaries (including raw data) are submitted to the laboratory section manager for review. This is the procedure for all analytical data. After approval, data are subsequently entered into the project database format.

1.13.2.2 Laboratory Data Validation

In addition to the data review performed by the analysts and the appropriate laboratory section manager, an external organization to the one that generated the data will validate the analytical data. Analytical data will be reviewed by the Project Manager and assessed by a qualified chemist, using a step-by-step approach. Approximately 10 percent of the data generated by the laboratory will be subjected to validation against DQOs using USEPA validation procedures for specified analytes.

Qualified data will be annotated in accordance with USEPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review, using the following codes:

- U - The analyte was analyzed for, but was not detected above the associated value.
- J - The associated numerical value is an estimated quantity.
- R - The data are unusable. The presence or absence of the analyte cannot be verified from the existing data. Re-sampling and re-analysis is necessary for verification.
- UJ - The analyte was analyzed for, but was not detected above the reported value. The associated value is an estimate.

In addition, the following data qualifiers may be used for organic data:

- N - There is presumptive evidence to make a tentative identification.

- NJ - There is presumptive evidence to make a tentative identification and the associated numerical value is an estimated quantity.

1.13.2.3 Laboratory Data Reporting

Laboratory analytical results will be reported as soon as results are available and will follow USEPA requirements in order to provide defensible evidence files. The standard laboratory data reports for organic compound analysis will consist of a transmittal letter and the following:

- A cover page describing data qualifiers, sample collection, extraction and analysis dates, and a description of any technical problems encountered with the analysis.
- Sample data including quantitation limits.
- Summary of QC data, including laboratory blanks, matrix spike/matrix spike duplicates, and surrogate recovery results.

The standard laboratory data reports for inorganic constituent analysis will consist of a transmittal letter and the following:

- A cover page describing data qualifiers, sample receipt, digestion and analysis dates, and a description of any technical problems encountered with the analysis.
- Sample data including quantitation limits.
- Summary of QC data, including laboratory blanks, and matrix spike/matrix spike duplicate results.

1.14 Performance and System Audits

Audits may consist of two types: system and performance audits. The purpose of a system audit is to determine whether appropriate project systems are in place. Performance audits are used to indicate whether those systems are functioning properly. Audits will be conducted by the QA/QC Manager or a designated appointee as tasked by the Program or Project Manager, to verify the existence of an effective QA/QC system. Additionally, the audit will evaluate the level of compliance of that system in terms of adherence to QA/QC measures, standards, records, and project documentation and control.

1.14.1 Project System Audits

The QA/QC Manager may periodically, on an unannounced basis, call for a system audit. The Project Manager will respond by submitting the QAPP. The audit will be performed by the QA/QC Manager or a designated appointee. The auditor will then determine whether the QAPP is in place and whether the reviews called for by the QAPP have been performed. Results of project audits will be reported to the Project Manager and Program Manager.

1.14.2 Technical Performance Audits

Technical performance audits will be conducted by the project QA/QC Manager on an ongoing basis during the project, as field data are generated, reduced, and analyzed. All numerical analyses, including manual calculations, mapping, and computer support activities, will be documented and subject to performance audits in the form of QC procedural reviews, mathematical reanalysis, and peer review. Technical peer review is the responsibility of the Project Manager. All records of numerical analyses will be legible, reproduction quality, and complete enough to permit logical reconstruction by a qualified objective reviewer.

1.14.3 Field Audits

A field performance audit will be conducted during each phase of the investigation and will include field sampling and associated sample handling and decontamination techniques. The purpose of the field audit is to ensure that proper methods and protocols detailed in this QAPP are consistently practiced in the field.

Audits will be performed using tailored checklists prepared by the QA/QC Manager. The requirements and audit questions to be developed will be as specific as possible and will focus on significant investigation techniques. Checklists are encouraged to be completed to the maximum extent possible to give a complete picture of field techniques using a structured approach.

Field operation records will be reviewed to verify that field-related activities were performed in accordance with appropriate project procedures. Items reviewed will include, but are not limited to, field equipment calibration records, daily field logs, and chain-of-custody documentation.

Upon audit completion, an audit report containing observations, findings, and recommended corrective actions will be submitted to the Project Manager and the Program Manager.

1.14.4 Laboratory Audits

The laboratory QA manager has responsibility for monitoring the internal QA program. The contractor will verify that standardized QA programs are in effect to provide objective oversight of laboratory procedures. Additionally, copies of internal QA reports will be requested to ensure that standards of quality performance are in effect.

1.15 Preventive Maintenance

Proper preventive maintenance of field and laboratory equipment is an essential element in a successful field investigation. Implementation of standard preventive maintenance routines serves to eliminate surprise equipment failures and subsequent stand-by time.

1.15.1 Field Equipment

Field equipment will be properly calibrated, charged, and in good working condition before the beginning of each working day. Manufacturers' specifications define the required equipment checks for each type of field equipment used. Non-operational field equipment will be removed from service and a replacement will be provided immediately. Significant repairs to field equipment will not be performed in the field.

All field instruments will be properly protected during the field investigation against inclement weather. Each instrument is specially designed to maintain its operating integrity during variable temperature ranges that are representative ranges that will be encountered during working conditions. At the end of each working day, all field equipment will be taken out of the field and placed in a cool, dry room for overnight storage.

All subcontractor equipment (e.g., drill rigs) will arrive at the site in proper working condition each day. All lubricating and hydraulic motor oils will be checked by the subcontractor before the start of each work day to ensure all fluid reservoirs are full and there are no leaks. Before the

start of each work day, the Site Manager will also inspect subcontractor equipment for fluid leaks. If a leak is detected, the equipment will be removed from service for repair or replacement.

1.15.2 Laboratory Equipment

The ability to generate valid analytical data requires that all analytical instrumentation be properly maintained. The selected laboratory should maintain full service contracts on all major instruments. These service contracts will not only provide routine preventive maintenance, but will provide emergency repair service to ensure responsive support to the project requirements.

1.15.2.1 Instrument Maintenance Logbooks

Each analytical instrument is assigned a specific instrument logbook. All maintenance activities are recorded in the instrument log. The information entered in the instrument log will include the following:

- Date of service;
- Person performing service;
- Type of service performed and reason for service;
- Replacement parts installed (if appropriate); and
- Other information, as required.

1.16 Specific Routine Procedures Used to Assess Data Precision, Accuracy, and Completeness

The QA objectives for precision, accuracy, and completeness are discussed in Section 1.5. This section discusses the routine procedures used for assessing those criteria.

The initial responsibility to monitor the quality of an analytical system lies with the analyst. The analyst will verify that all QC procedures are followed and the results of analysis of QC samples are within acceptance criteria. If acceptance criteria limits are exceeded, this must be described in the analytical report case narrative. This requires that the analyst evaluate the results for the following laboratory QC items, as appropriate:

- Sample preparation procedures;
- Initial calibration;
- Calibration verification;
- Method blanks;
- Duplicate analyses;
- Laboratory control standards; and
- Spiked samples.

1.17 Corrective Action Protocols

The QA/QC Manager and audit team will prepare a formal report of any audit proceedings. The programmatic impact of a negative finding, such as failure to use an appropriate procedure, will be determined by the QA/QC Manager or lead auditor and reported to the project management staff. A corrective action plan and implementation schedule will be required, and the Project Manager will be responsible for ensuring that immediate action to correct the nonconformance has been initiated. The Project Manager will be responsible for ensuring the successful implementation of the corrective action plan and ensuring that no additional work that is dependent on the nonconforming action is performed until the nonconformance is corrected. Corrective actions may include reanalyzing samples (if holding times permit), resampling, and evaluating and amending sampling and analytical procedures.

The Project Manager will be responsible for ensuring that the corrective action adequately addresses the nonconformance. The QA/QC Manager will ensure that corrective actions for nonconformances are implemented by:

- Evaluating reported nonconformances;
- Controlling additional work on nonconforming items;
- Maintaining a log of nonconformances; and
- Ensuring that all Nonconformance and Corrective Action Reports are included in the project files.

Following implementation of satisfactory corrective action, the QA/QC Manager will conduct sufficient follow-up activities to verify the corrective action. Such confirmation will be documented, along with any other recommendations, in a formal close-out of the audit. The close-out report will be distributed to appropriate project management personnel.

1.17.1 Field Corrective Action

The initial responsibility for monitoring the quality of field measurements and observations lies with field personnel. The Site Manager is responsible for verifying that all QC procedures are being followed in the field. This requires that the Site Manager assess the correctness of field methods and the ability to meet QA objectives. If a problem occurs that might jeopardize the integrity of the project or cause some specific QA objective not to be met, it is the responsibility of field project staff to report suspected nonconformances by initiating a Nonconformance and Corrective Action Report (Figure B-2) and submitting it to the Project Manager.

The Project Manager will submit a copy of the Nonconformance and Corrective Action Report to the QA/QC Manager for a formal investigation. An appropriate corrective action will then be developed and implemented.

1.17.2 Laboratory Corrective Action

If the analyst's assessment of the laboratory QC items identified in Section 1.16 reveals that any of the QC acceptance criteria have not been met, as defined by the Laboratory QAPP or USEPA method protocols, the analyst must immediately assess the analytical system to correct the problem. The analyst notifies his/her supervisor, section leader, or QA coordinator of the problem, and, if possible, identifies the potential cause(s) and makes appropriate corrective action recommendations.

The identification of the corrective action obviously depends on the nature of the problem. For example, if a continuing calibration verification is determined to be out of process control, the corrective action may require recalibration of the analytical system and reanalysis of all samples since the last acceptable continuing calibration standard.

Sample-related QC samples (e.g., matrix spikes and matrix spike duplicates) provide an indication of matrix effects on analyses and do not

Nonconformance and Corrective Action Report

Date: _____
ERM-West Project Number: _____

SUBMITTAL

To: Project Director
QA/QC Officer

Description of Nonconformance and Cause:

Proposed Corrective Action:

Submitted By: _____ Location: _____
Approved By: _____ Date: _____

CORRECTIVE ACTION (by Project Manager or Designee):

Implementation by Action assigned to:

Actual Corrective Action:

Implementation verbally approved by QA Officer on _____
(date)

Action implemented on _____
(date)

(Signature)

VERIFICATION (by QA/QC Officer or Designee)

Corrective Action implementation reviewed and Work Inspected by:

on _____

Corrective Action Verified by on _____

Figure B-2

Nonconformance and Corrective Action Report

require reanalysis if method-related QC samples (e.g., method blanks, method spikes, and method spike duplicates) indicate acceptable performance.

When the appropriate corrective action measures have been defined and implemented and the analytical system is determined to be in control, the analyst documents the problem, the corrective action, and the associated data, thereby demonstrating that the analytical system is in control. Copies of the documentation are provided to appropriate management staff members and the QA/QC Manager for review and addition to the project files.

1.18 QA Reports to Management

The ANG Project Manager will rely on written reports and memoranda documenting data assessment activities, quality audits, nonconformances, corrective actions, and quality notices. A copy of all significant QA reports will be forwarded to the Program Director for review and oversight.